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RECORDS OF OCEANOGRAPHIC WORKS IN JAPAN

Special Number 4

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FOREWORD

Present issue contains some of the reports for 1958 on the researches conducted under the oceanographic research project of the Japanese National Commission for Unesco, which is continued since 1953 with the participation of many distinguished marine scientists in Japan.

In 1958, the emphasis was placed on basic researches on the marine productivity and its utilization in the Kuroshio region, such as the Inland Sea and seas near Kyushu, Shikoku and Kii Peninsula.

It is hoped that this publication will be of help to all the students abroad interested in marine sciences.

March 1960

Yoshio Muto
Secretary-General
Japanese National Commission
for Unesco

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Records of Oceanographic Works
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March 1960

A STUDY ON THE PRODUCTIVITY OF TANABE BAY

Tidal Currents in Tanabe Bay
(3rd Report)

By
Akikazu Nakamura
(Osaka University of Liberal Arts and Education)

Period of Observation

The strong tidal currents of Tanabe Bay were measured in the following two periods.

(A) The first period: From 1st to 4th, July, 1958.

(B) The second period: From 11th to 13th, November, 1958.

Method of Observation

The tidal currents in the surface layers were observed by both "drift-bottle" method and cup-type current meter method as was reported in the second report. Besides, the currents at the arbitrary depths between the surface and the bottom were intermittently measured during the comparatively long time intervals by useing the CK-type current meter, manufactured by the Nippon Kaiyo Kiki Co.. In the first period of observation, the velocity device of the CK–type current meter was broken down soon after the beginning of the observation and only the direction of the current was determined. This instrument, having been sent for repairs, was used in the second period of observation, but the velocity device went wrong once again. Having had no time for repairs, we were obliged to observe the current-direction only at the deeper layers as in the first period.

To make matters worse, the weathers were generally unfavorable for our observations throughout both the periods. Therefore, the data obtained were far less than we expected.

The tides were observed with the tide staff at Rinkai-ura (the northern coast of the Seto Marine Biological Laboratory) in the first period and with the tape gauge at a well of the Laboratory in the second period, the tidal phase at the well being ten minutes later than the one at Rinkai-ura.

Results of Observation

The First Period of Observation

Observations were made at seven stations as shown in Fig. 1. In Figs. 2–a, b and c are shown the marigrams obtained during this period, and results

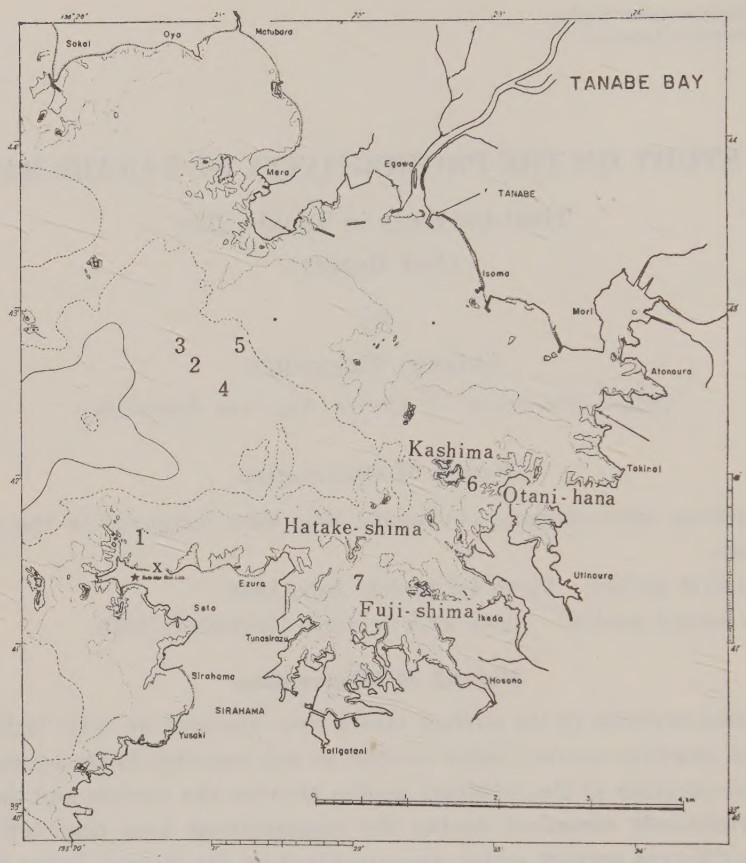


Fig. 1. Chart showing the stations during July 1–4, 1958. Number indicates the location of station, the X mark shows the place of tide observation.

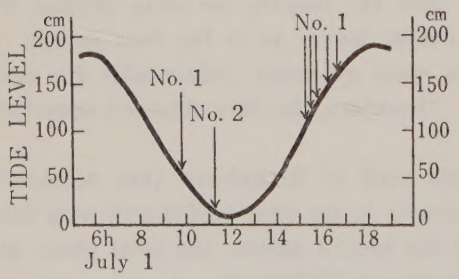


Fig. 2–a. Marigram at Rinkai-ura on July 1. Each arrow points to the tide level at the time when each current at Nos. 1 and 2 was observed.

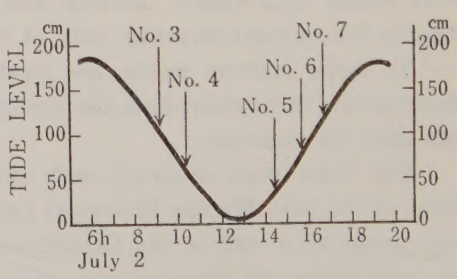


Fig. 2–b. Marigram at Rinkai-ura on July 2. Each arrow points to the tide level at the time when each current at Nos. 3–7 was observed.

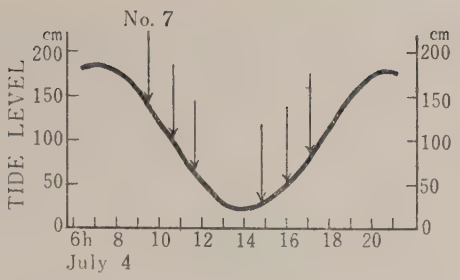


Fig. 2–c. Marigram at Rinkai-ura on July 4. Each arrow points to the tide level at the time when each current at No. 7 was observed.

are given in Tables 1, 2 and 3.

Off the Laboratory: In the middle of the ebb tide on the morning of July 1st, the only observation was made at No. 1, where the current flows toward the north at the depth of 0.5 m and turns to the west-southwest at the depths of 1.0~5.0 m, but it takes the various and unsettled directions at the depths of 7.0~8.0 m, showing the northeasterly flow at the depth of 9.0 m. And, during the middle and its neighborhood of the flood tide, observations were made intermittently for one and a half hour at No. 1. There exist various and rather

Table 1. Currents at No. 1

Time	July 1 09h50m	15h15m	15h30m	15h45m	16h15m	16h40m
Wind	NW 2.1*	Calm	Calm	Calm	Calm	Calm
Depth (m) 0.5	N	SSW	S	SSE 6**	S 9	SSE 11
1.0	WSW	SSE	SSE	SW 7	WNW 10	S 9
1.5	WSW	NNW	SSE	SSE 8	WNW 7	SSE 9
2.0	WSW	S	SSE	ENE	NE 7	NE 9
3.0	WSW	ENE	NNW 6	ESE	ESE 7	WSW 8
5.0	WSW	N	NE	ESE	NE	NE
9.0	NNE	NW	NW	N	NW	N

* : Wind-velocity in (m/s).
** : Current-velocity in (cm/s).

unsettled flows at the depths of 0.5~9.0 m; i.e., a southerly one at the depth of 0.5 m; a southerly, sometimes westerly or easterly one at 1.0~1.5 m; a southerly, subsequently northeasterly one at 2.0 m; a most unsteady one at 3.0 m; a

northeasterly one at 5.0 m; a northwesterly or northerly one at 9.0 m; and their velocities are 6~11 cm/sec and less than 5 cm/sec at the depths above and below 5.0 m respectively.

The central area of the mouth of the bay: The current at No. 2 was observed near the low water. The surface layer of about 1.0 m in thickness shows the northwesterly outflow of 14 cm/sec and the direction of the current turns to the north-northwest at the depths of 1.5~3.0 m, inversely to the south at 5.0~15.0 m, again to the northwest at 20.0 m, and to the west-southwest at 25.0 m, the current velocities being less than 5 cm/sec at the deeper layers below the depth of 3.0 m.

Table 2. Currents at Nos. 2, 3, 4 and 5

Station	No. 2	No. 3	No. 4	No. 5
Time	July 1 11h15m	July 2 09h10m	10h20m	14h25m
Wind	WSW 4.0*	S 7.5	S 4.5	SW 7.0
Depth(m) 0.5	NW 14**	SSW	SSW	NE
1.0	NW 14	SSW	SSW	NE
1.5	NNW 7	SSW	SSW	ENE
3.0	NNW	—	SSW	ENE
5.0	S	—	S	ENE
10.0	S	—	SSW	SSE
15.0	S	—	SSW	SSE
20.0	NW	—	SSW	SSE
25.0	WSW	—	SSW	—
30.0	—	—	SSW	—

* : Wind-velocity in (m/s).
** : Current-velocity in (cm/s).

Observation at No. 3 was stopped owing to the rather strong south wind of 7.5 m/sec after observing the south-southwesterly flows at the surface layers above 1.5 m. The current at No. 4 in the middle of the ebb tide runs in the south-southwest direction at all the depths from the surface down to the bottom against the south wind of 4.5 m/sec.

The boat, having been anchored at No. 4 for the purpose of measuring currents, was driven as far as to the position of No. 5 in the course of four hours by the strong southwest wind. The current at No. 5 shows the inflow at the tide level between the low water and the middle of the flood; i.e., a northeasterly one at the surface layers above 1.0 m and an east-northeasterly one at the depths of 1.5~5.0 m, both drifted by the southwest wind which keeps

Table 3. Currents at Nos. 6, 7 and 8

Station	No. 6	No. 7							No. 8
Time	July 2 15h40m	July 2 16h40m	July 4 09h30m	10h40m	11h40m	14h50m	16h00m	17h05m	Nov. 11 15h50m
Wind	SSE 4.6*	S 5.4	SSE 6.8	SSE 5.0	SW 3.5	SSW 4.4	WSW 2.9	W 3.0	NW 5.0
Depth (m)									
0.5	NNE 14**	N 13	NNE	NE 11	ENE 9	ENE	E 6	ENE 7	W 6
1.0	—	NNE 13	NNE	NE 6	NE	E	E 6	ESE 7	WSW 7
1.5	ENE 12	NE 10	NNE	NNE	NE	ENE	E	SSE 8	SW 6
2.0	—	ESE 8	NNE	SSW	SE	ESE	SSE	SSE 7	SW 10
3.0	ESE 7	ESE 8	ENE	WNW	SSE	SW	SSE	S 6	SSW 11
5.0	—	WSW	NNW	N	SSE	W	WSW	WSW	S
10.0	—	ENE	W	W	WNW	WNW	S	E	—
15.0	—	NNW	ESE	ESE	SSW	E	ESE	NNW	—

* : Wind-velocity in (m/s).

** : Current-velocity in (cm/s).

blowing at about 7.0 m/sec; and a south-southeasterly one at the deeper layers below the depth of 10.0 m.

The inner bay: Only the two stations of Nos. 6 and 7 were observed. At No. 6, being located between Kashima and Otani-hana, the current in the middle of the flood turns its direction from the north-northeast to the east-northeast, then to the east-southeast and diminishes its velocity from 14 cm/sec to 12 cm/sec, then to 7 cm/sec according to the increase of depth from 0.5 m to 1.5 m, then to 3.0 m. And at No. 7, lying between Hatake-shima and Fuji-shima, the current was observed frequently on both ebb and flood tides. During the ebb tide, there exist the flows of various direction at all the depths; i.e., a northeasterly one at the surface layer of about 1.5 m in thickness; a northerly, then southerly or southeasterly one at the depth of 2.0 m; an easterly, then westerly or southerly one at 3.0 m; a northerly, then southerly one at 5.0 m; a westerly one at 10.0 m; an easterly, then southerly one at 15.0 m. While, during the tide level from the low water to the middle of the flood, there flows the current different from the one during the ebb as follows; an easterly flow at the surface layer of about 1.0 m in thickness; an easterly, then southerly one at the depths of 1.5~2.0 m; a southwesterly, then southerly one at the depth of 3.0 m; a westerly one at 5.0 m; a westerly, then southerly and easterly one at 10.0 m; and an easterly, then northerly one at 15.0 m.

The Second Period of Observation

Observations were made at four stations as shown in Fig. 3. The marigrams are shown in Figs. 4–a and b, results being given in Table 4.

The inner bay: The only observation was made at No. 8 in the vicinity of No. 7, which shows the current at the middle of the flood dissimilar to the one at No. 7 as shown in Table 3; i.e., the direction turns from the west to the southwest and then to the south according as the depth increases from 0.5 m to 5.0 m, while the velocity is quicker at the depths of 2.0~3.0 m than at the upper layers above the depth of 1.5 m.

The central area of the mouth of the bay: The current at No. 9 was observed near the low water, which shows the direction turning from the south-southeast at the depth of 0.5 m to the south-southwest at 1.0 m, then to the southwest at the deeper layers below 1.5 m (down to the bottom) against the southwest wind of 2.5 m/sec. Observation at No. 10 was made just at the low water, showing the outflow at all the depths except the depth of 10.0 m (flowing south) against the rather strong southwest wind of 6.0 m/sec. The current at No. 11 was observed at time intervals of a half or one hour during the period of semi-diurnal tide on Nov. 12th and 13th. Observations, having been scheduled to continue till thirteen o'clock on Nov. 13th, were given up after ten o'clock because the strong wind of over 8 m/sec began to blow and the conditions of the sea became unfavorable for our operations.

The correlation between the direction of the current and the tide level can be described as follows.

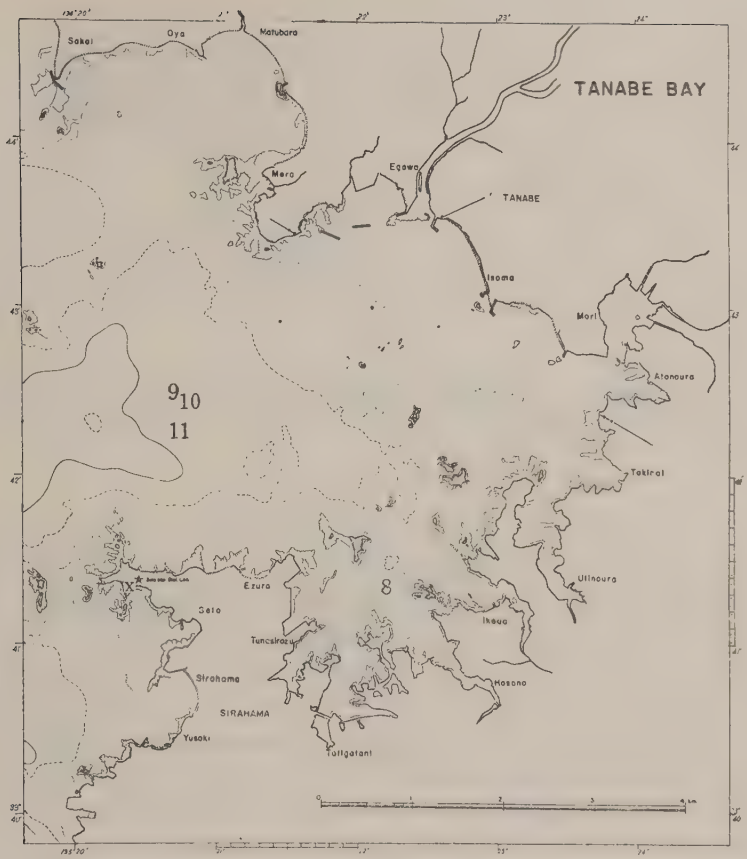


Fig. 3. Chart showing the stations during November, 11–13, 1958. Number indicates the location of station, the x mark shows the place of tide observation.

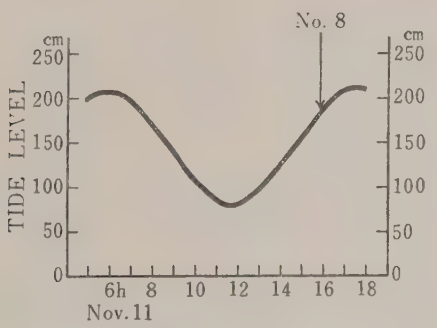


Fig. 4–a. Marigram at the well of Laboratory on Nov. 11. An arrow points to the tide level at the time when the current at No. 8 was observed.

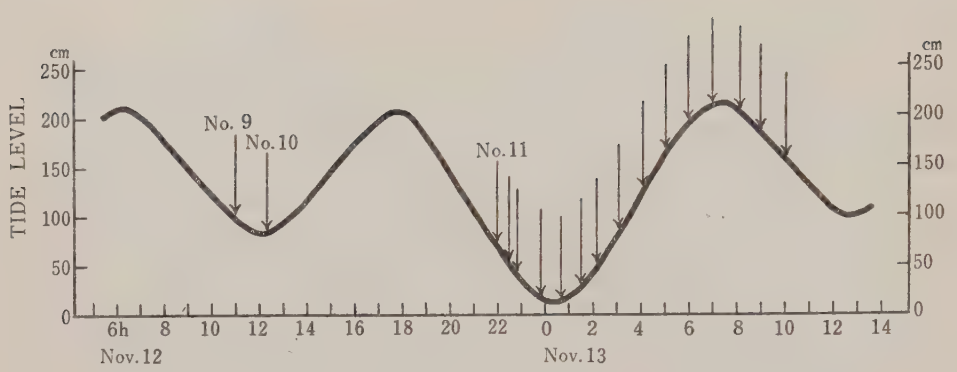


Fig. 4–b. Marigram at the well of Laboratory on Nov. 12–13. Each arrow points to the tide level at the time when each current at Nos. 9–11 was observed.

The current, in general, changes its direction much more frequently during the ebb tide than during the flood. There were various flows into or out of the bay during the latter half of the ebb tide on the night of Nov. 12th; i.e., a southerly or southwesterly outflow, subsequently southeasterly or easterly inflow at the surface layer of about 2.0 m in thickness; a southwesterly outflow, then east-southeast inflow at the depths of 3.0～5.0 m; a southerly occasionally southeasterly flow at 10.0～25.0 m; and a southeasterly or east-southeasterly inflow near the bottom (29.0～30.0 m). Close to the low water, the current at the layers above the depth of 15.0 m runs east, while the flows at the depths of 20.0～25.0 m and near the bottom (28.0 m) turn toward the north-northwest and the south-southwest respectively. And just at the low water, the easterly or northeasterly inflow runs at all the depths, though the current at the upper layers above the depth of 10.0 m takes the unsettled direction.

During the flood on the morning of Nov. 13th, the current flowed uniformly toward the east at all the depths except near the bottom where the irregular current flowed due to the topography. In the vicinity of the high water, there exist the southeasterly or easterly inflows at the upper layers above the depth of 20.0 m, the southerly one at the depth of 25.0 m, and the southwesterly outflow near the bottom (30.0 m). It is noteworthy that the current at the deeper layers below the depth of 15.0 m takes the unsettled direction near the high water, just as the upper layers above the depth of 10.0 m show during the ebb tide.

From the high water to the middle of the ebb tide, the current keeps its direction toward the southeast or east at the surface layers above the depth of 10.0 m, but it turns to the southwest at the depths of 15.0～20.0 m, to the west at 25.0 m and to the northwest at 30.0 m near the bottom.

Furthermore, the distinctive features of the current at No. 11 throughout these observations can be outlined as follows.

Table 4. Currents at Nos. 9, 10 and 11 (a)

Station	No. 9	No. 10	No. 11					
Time	Nov. 12 11h00m	12h20m	22h00m	22h30m	22h50m	23h50m	Nov. 13 00h40m	01h30m
Wind	SW 2.5*	SW 6.0	NE 3.0	NE 4.0	NE 5.3	NE 2.5	E 3.7	ENE 3.2
Depth(m) 0.5	SSE	SW	S	SE	ENE	E	N–ESE (ENE)	NE
1.0	SSW	SW	SSW	SE	ENE	E	N–SE (ENE)	NE
1.5	SW	WSW	SW	SE	NE	NE–E (ENE)**	N–E (NE)	NE
2.0	SW	WSW	SW	SE	NNE–WSW (ESE)	ENE	N–ENE (NE)	NNE
3.0	SW	WSW	NNW–WNW (NW)	SW	NNE–SW (ESE)	N–ENE (NNE)	N–E (NE)	NE
5.0	SW	WSW	NW–SW (W)	SW	ESE	N–E (NE)	NE	NE
10.0	SW	S	NNW–SW (W)	S	SE	NE–ESE (ENE)	NNE–ENE (NE)	NE
15.0	SW	NW	S	SSE	SE	NE–SE (E)	E	E
20.0	SW	WSW	SE–SSW (S)	S	S	NNW	ENE	E
25.0	SW	W	SE–SW (S)	S	SSE	NNW	ENE	E
Bottom	SW (30)***	W (30)	SE (30)	SE (30)	ESE (29)	SSW (28)	ENE (28)	E (28)

* : Wind-velocity in (m/s).

** : The most frequent current-direction.

*** : Bottom-depth in (m).

Table 4. Currents at Nos. 9, 10 and 11 (b)

Station									
Time	02h10m	03h05m	04h05m	05h05m	06h00m	07h00m	08h10m	09h00m	10h05m
Wind	ENE 0.5	NE 3.7	ENE 5.2	ENE 3.2	E 4.1	E 5.4	ESE 5.5	ESE 6.5	WNW 8.3
Depth(m) 0.5	N	ENE	E	E	E	SE	SSE	SE	SSW
1.0	N	ENE	E	E	E	ESE	SE-SW (S)	SE	E-SW (SSE)
1.5	N	NE	E	E	E	ESE	NE-SE (E)	SSE	NNW-WSW (E)
2.0	NNE	NE	E	E	E	ESE	ENE-SSE (ESE)	NNE-SSE (E)	ENE
3.0	NNE	ENE	E	E	ESE	ESE	E-SE (ESE)	SE-S (SSE)	ENE
5.0	NE	ENE	E	E	ESE	E	E-S (SE)	E-S (SE)	E-SSE (SE)
10.0	ENE	E	E	E	E	E	E	ESE	SSE-WNW (SW)
15.0	NE-E (ENE)	E	E	NE-E (ENE)	E	ENE-ESE (E)	NE-SW (SE)	SSE	SW
20.0	ESE	E	ESE	E	E-SSE (ESE)	ENE-S (SE)	NE-WNW (S)	S-WSW (SW)	S-W (SW)
25.0	ESE-SSW (SSE)	E	ESE	ENE-SE (ESE)	E-SSW (SSE)	SE-SSW (S)	ESE-SW (S)	SW-W (WSW)	SW-N (WNW)
Bottom	SSW (28)	N (29)	ESE (29)	SE (30)	WSW (30)	SW (30)	WSW (30)	NW (30)	NW (30)

1. The surface layer of about 3.0 m in thickness shows almost always the similar flow.
2. The current at the depths of 5.0~15.0 m, especially at the depth of 10.0 m, takes the most settled direction, and the turn of its direction is the least at the depth of 15.0 m.
3. The flow at the deeper layers below the depth of 20.0 m changes its direction in wide range.
4. The movement of the water mass near the bottom is greatly irregular chiefly due to the topography.

The present observations are, indeed, unsatisfactory for discussing the tidal currents in the bay. It is the author's earnest wish to attempt the more frequent and accurate observations with an improved instrument in the near future.

Records of Oceanographic Works
in Japan (Special Number 4)
March 1960

A STUDY ON THE PRODUCTIVITY OF TANABE BAY
(Part III)
Oceanographic Conditions of Tanabe Bay (3)
Result of the Survey in the Summer of 1958

By
Shin-ichiro Fuse and Eiji Harada
(Seto Marine Biological Laboratory, Kyoto University)

Introduction

We have made several surveys in order to make clear the concrete structures of marine bio-productive systems in Tanabe Bay. Then it was elucidated by the first survey carried out in the autumn (November) of 1956 (Fuse, Yamazi and Harada, 1958) that the bay water was well mixed vertically and by the second survey carried out in the summer (August) of 1957 (Fuse, 1959) that the bay water was stratified. In this report, we describe the horizontal distribution of oceanographic conditions and also the stratification of bay water, based on the third survey carried out in the summer of 1958.

Method, Location of Survey Stations and Meteorological Conditions

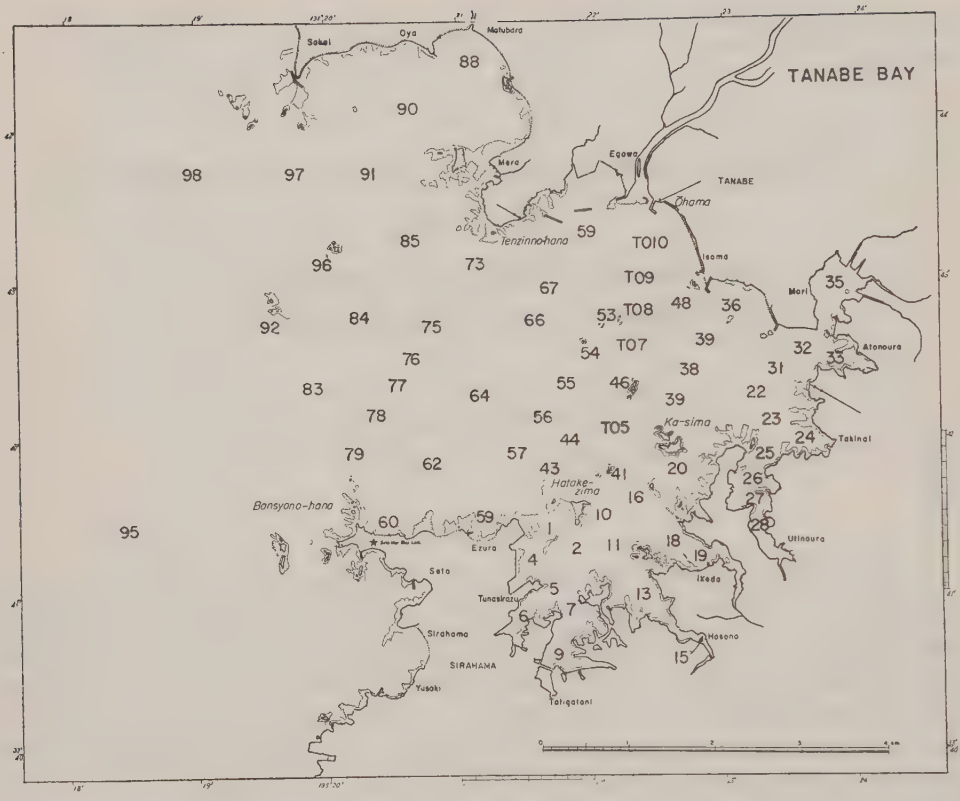
The present observation was made at each of 5 new stations and 64 stations which were a part of 100 stations of the first survey, from 07:00 to 19:00, on August 5th 1958, on board a surveying boat. The distribution and the number of stations are the same as the first report (Fuse *et al.* 1958).

St. T05 among the 5 new stations is located between St. 41 and St. 46, and other 4 stations (T07, T08, T09 and T010) are located at an equal interval along the line from St. 46 to Ôhama (near the river mouth of Aizu-gawa).

Water sampling was made at each of observational layers such as 0 m, 5 m, 10 m, 20 m and 30 m in depth and the bottom. The surface water was collected with T. S. transparent insulated bottle (made by plastic resin with a thermometer attached in the bottle), and 20 m and 30 m water with a Nansen bottle. Bottom water was collected with a Kitahara's insulated bottle, approaching the bottom as near as possible.

Within two days following the field survey, water samples were treated chemically in the laboratory by the same methods as previously reported.

It was usually cloudy (amount: 10, form: Cu) during this field survey, but began to rain at 15:36 and soon, about 5 minutes after, cleared up.



Map of surveyed area

Results

The list of stations and full data on the horizontal distribution of chlorinity, water temperature, silicates and phosphates content and pH are given in Tables 1~6 appended at the end of this report.

Colour of Sea (Table 1)

Colour varied from Forel's no. 3.5 at St. 95 in the outermost part of the bay to no. 9 in Mori arm. In general, the same coloured lines nearly coincided with isobath lines, showing a tendency to become larger landwards and inwards of the bay. In the southwestern part of the bay, this general tendency was lost to become comparatively bluish, contour of no. 5.5 being protruded to the east of Hatake-zima islet.

It is suggested by these phenomena that the open sea water passed through the southern part of the bay and entered to the east of Hatake-zima.

At all observational stations, colour was more bluish by 1 of Forel's scale than that of the first survey.

Transparency (Table 1)

The transparency measured by Secchi's disc was from the maximum of 13.5 m at St. 95 to the minimum of 3.5 m at St. 35. The contour lines of different transparent parts showed strong similarity to those of the sea colour, showing

a general tendency to become smaller landwards and inwards of the bay. As based on the transparency distribution pattern, the same water movement is suggested as in the case of colour.

Chlorinity (Table 2)

Chlorinity ranged between 19.30 ‰ (bottom, St. 98) and 18.53 ‰ (0 m, St. 35 in Mori arm). At every station, the chlorinity of the surface layer was the lowest, and the higher chlorinity was observed in the deeper layer.

Horizontal distribution pattern was rather different between shallower and deeper layers. At the surface, isohaline lines were parallel to the direction of NW~SE in the bay, and the lowest chlorinity of Mori arm became higher gradually towards southwest of the bay. There was wide region where chlorinity was equal (18.80 ‰) in the innermost part of Hatake-zima~Ka-sima line except Tunasirazu and Kogaura arms.

On the bottom, chlorinity showed a tendency to become lower landwards and inwards of the bay. A bottom chlorinity was higher than that of the same depth layer which was not the bottom at other stations.

On the 20 m layer, isohaline lines were parallel to the line from Bansyono-hana to Tenzinno-hana in the direction of NE~SW in the bay. In the shallower parts, this character was not distinct. It seems to be the effect of bottom chlorinity.

On the 5 m and 10 m layers, the distribution of chlorinity showed no remarkable tendency, for these intermediate layers were affected by both the surface and the deeper chlorinities, distributions of which are quite different.

Water Temperature (Table 3)

The highest water temperature (30.30°C) was found at the surface of St. 35, and the lowest (22.92°C) was found on the bottom of St. 92. And in vertical, the temperature was the highest at the surface, and became lower towards the bottom at every station.

The surface temperature was the highest in the northeastern part of the bay and became lower in the southwestern part and the isothermal line ran almost parallel to the direction of NW~SE. Distribution patterns of water temperature and chlorinity are quite alike on the west side of the Hatake-zima line, extending to St. 48 (i.e. outer part), but not on the east side of the same line (i.e. inner part) at the surface. The difference is probably due to the fact that the observation was made in the inner part in early morning when temperature was more or less low and the lower temperature than that in other plate was observed.

On the 5 m and 10 m layers, which are intermediate between 0 m and 20 m layers, water temperature had no remarkable tendency in its horizontal distribution.

On the bottom, the lower temperature was found in the more open part and become higher in the vicinity of coast and inner parts. Especially, it was the highest in temperature off the estuary of Aizu River, Mori arm and Atonoura

arm. There are many stations where the bottom temperature was lower than that of the same depth in the intermediate.

Silicates

Content of silicates was found the minimum of 0 Si μg-atoms/L at the surface in the outer part and in the open part and the maximum of 25.9 Si μg-atoms/L on the bottom in Kogaura arm. The lower quantity was observed on the shallower layer and the higher was found on the deeper.

Surface silicates became higher coastwards, and lower towards the outer part and open sea.

On the 5 m layer, silicates did not show such characteristic tendency as to become higher in the coastward parts, but there was found more silicates all over the bay and less in the open sea, and there was more silicates than at the surface.

On less than 10 m layer and 20 m layer, silicates was measured to be the same value of 3~4 Si μg-atoms/L.

On the bottom, a lot of silicates (Si 3 μg-atoms/L) was found at almost all stations and the greatest in the arms.

Phosphates

Phosphates varied between 0 and 0.79 P μg-atoms/L. Its content was higher in the innermost part than in the outer part of the bay horizontally, and higher on the deeper layer than on the shallower layer vertically.

At the surface, phosphates was the highest in the arms (Tunasirazu: 2.6 P μg-atoms/L, Kogaura: 7.9 P μg-atoms/L) and rather lower in the inner part of the bay and little in the outer part and the open sea.

On each of 5 m~30 m layers, there was found a tendency that phosphates content becomes rather uniform at all stations on the deeper layers (Table). Hence, the horizontal distribution of P-content showed no remarkable pattern.

P μg-atoms/L	0 m	5 m	10 m	20 m	30 m	bottom
average	0.0294	0.0263	0.0459	0.0808	0.1346	0.1742
maximum deviation	0.658	0.223	0.284	0.0850	0.0321	0.613

On the bottom, the inorganic phosphates content was found relatively higher in the innermost of the bay, especially in the arms, becoming less in the outer part and little in the open sea.

pH

Lower value of pH (8.3) was observed on the bottom only. On other layers, pH was 8.4 and uniform in all over the bay.

Discussion

Vertical Stability of Bay Water

The vertical range of water temperature was about 5°C and that of chlorinity was 0.5 ‰. These differences are of the same grade as in the second

survey carried out in August of 1957 (Fuse, 1959). The water temperature was the highest at the surface and became lower on the deeper layers and the chlorinity was the lowest at the surface and became higher on the deeper layers, thus the bay waters were stratified and stable vertically.

Previously, in November (the first survey of 1956), no vertical stability was found, but in August (the second survey of 1957), stratification was observed on two sectional lines both in the mouth and in the innermost part of the bay. In the present survey, such phenomena of stratification became evident at all stations as a general tendency of the character of summer bay water.

On the Phosphates and Silicates

The less phosphates and silicates content of the surface water and the more content of the deeper one prove that inorganic P and Si are accumulated in the deeper water, as the bay water is stable with strata. Though there remain several concrete relationships to be solved, it may be due to, more or less, the effects of some biological elements that the stratification of P and Si was not so clear as in the cases of the chlorinity and water temperature.

From the evidence of the less phosphates content in the intermediate water, in comparison with the first survey in 1956, it is deduced that more consumption of phosphates took place by more quantity of plankton, which is suggested by the lower transparency and the bluish sea colour.

From the evidence of the less silicates generally in the bay too, the same is deducible. In addition, there is not so remarkable pattern as in the first survey in distribution of the silicates and chlorinity, because a lesser discharge of fresh water from the streams in the innermost arms must have occurred. And also such a lesser discharge of fresh water is a seasonal character.

The horizontal distribution gradient of the P and Si contents was different from that of chlorinity and water temperature, the former two having the gradient of increasing or decreasing in the direction of W~E, innermost part~ the bay mouth, while the latter two in the direction of NE~SW respectively. It is, therefore, inferred that such differences may be due to the effect of certain biological factors.

The fact that there is no gradient in winter but stratification in summer of the vertical distribution of phosphates and silicates was found in Mutu Bay (Okitu, 1952) and off Plymouth, England (Armstrong, 1958). As the similar evidence is seen in Tanabe Bay, some causal connexions between biological effects and nutrient matters are expected to exist.

On the Surface and Bottom Waters

There was considerable difference between the surface and the deeper water in the distribution of chlorinity. The isohaline line of the surface water ran parallel along the southwestern coast and reached the inner part of the bay. The same of the bottom water ran parallel to the direction of NE~SW. This difference did not occur in November, and hence it shows that on the surface

the effect of the open sea water on the bay water is different from that on deeper layers.

As shown in the summer distribution of chlorinity, it is presumable that open sea water enters the bay passing along the southern coast and the inner bay water flows out passing along the northern coast. This tendency is remarkable during summer in only shallow water of 0~5 m in depth.

For the bottom water, on the other hand, it seems that bottom water of open sea, enters the bay, passing through the middle of the mouth and central part of the bay.

The difference of water movement between the shallower and the deeper layers may be deduced also from other evidences. Namely, the waters of 0~5 m are well mixed by tidal current as reported on the second survey carried out along the sectional line of the bay mouth.

In November, bay water, mixed vertically by the surface cooling, may be affected on all layers from surface to bottom by the open sea water which enters the bay from the middle of the bay mouth and flows the central part inwards the bay under the northwesterly constant wind. Therefore, the horizontal distribution patterns of the chlorinity and temperature become to resemble each other.

For instance, the distribution of transparency and sea colour resembles that of chlorinity and temperature on all layers in November, but at the surface layer only in August.

Conclusion and Problems to Be Solved

The vertical distribution of hydrographic conditions in Tanabe Bay showed a clear stratification in August, and no stratification in November. Thus, it is deducible that the bay water is stable in August and is mixed verticaly in November.

Considering the horizontal distribution pattern of the hydrographic conditions, open sea water affects the bay water by two ways, one of which is to affect the shallower and deeper strata independently in August and the other is, through the northwesterly constant wind to affect all strata from the surface to the bottom in November. And the factor of the action of introducing the water exchange may not be so strong as the northwesterly constant wind in winter.

These phenomena must be of the seasonal character in summer and winter. Following this seasonal change, nutrient matters may also change seasonally in association with biologic actions. Especially on the phosphorus, the same seasonal changes are observed as reported by Sverdrup et al. (1942), Harvey (1955) and Armstrong (1958).

Studies should be made, therefore, on the transition from summer to winter conditions of the bay water as well as the nutrient matters.

There is also an important problem of the relationship between the waters of surface~intermediate layers and the vicinity of bottom.

In future, it may be expected to associate the known water condition with the production system of sessile algae and phytoplankton.

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Table 1. List of stations of Tanabe Bay for hydrological and biological observations on 5th August 1958

Station	Hour	Sounding (meters)	Water colour	Transp. (meters)	Weather	Wind	Sea	Air temp. (°C)
60	0712–0717	8–10 (9.4)	5	10+	o, Cu. Ns. –10	E–1	0–1	27.7
59	0724–0727	8 (7.5)	5.5	8+				
1	0734–0737	12 (11.8)	5.5	9.5				
4	0742–0752	12 (11)	5.5	7				
5	0748–0756	17.9(15.5)	5.5	7.5				
6	0800–0803	9.5(9.7)	7	6.1				
9	0811–0815	13 (11.9)	6.5	7.3				
7	0820–0824	17.5(16.6)	5.5	8.4				
2	0828–0832	14 (11.5)	5.5	9.6				
10	0831–0841	22 (20.8)	5	11.2				
11	0843–0848	20 (18.8)	5.5	10.5				
13	0853–0858	16 (14.5)	6	8.2				
15	0903–0905	3.2(3.2)	8.5	3+				
19	0918–0921	11.5(10.7)	7	6				
18	0922–0926	15 (13.4)	6	8.9				
16	0930–0935	20.4(18.6)	5.5	—				
41	0938–0945	26.5(24.8)	5.5	10.5				
20	0948–0952	18 (16.6)	6.5	8.2				
39	0958–1003	20 (18.6)	7	8.0				
38	1007	13 (13)	6.5	8.5	o, Cu, Ac. –9	W–0	0–1	30.0
22	1015	16 (16)	6.5	8.4		~1		
23	1026	16 (16)	6.5	8.1				
24	1035–1038	4.5(4.5)	8	4+				
25	1043–1048	15.5(15.5)	7.5	7.3				
26	1053	14.1(14.4)	8.5	6.9				
28	1102–1105	6.5(5.5)	6.1	4.4				
31	1116–1119	10.5(10.3)	7.5	7.9				
32	1122–	10.5(9.9)	8.5	5.7				
33	1128–1138	4 (3.3)	9	4+				
35	1140–1143	4.5(3.8)	9	3.5	rest for lunch:	1143–1205		
37	1212–1215	8.5(7.8)	6	6.4				
36	1218–	5.9(5.2)	7	4+				

48	1225–1229	7 (6.3)	7	6.0				
T10	1231	7 (6.8)	7	6.3				
T09	1237	8.1(7.7)	6.5	6.3				
T08	1242–1244	10.5(9.7)	6	8.0				
T07	1247–1249	12 (10.9)	6	7.6				
T06	1254–1256	9.1(9.9)	7	8+				
T05	1258–1305	30 (27.7)	6	7.5				
44	1309–1314	25 (24.1)	5	9.4	o, Cu. —8	W–2	0–2	31.2
43	1316–1321	22 (21.1)	6	7.5				
57	1324–1329	25 (22.1)	5.5	9.6				
56	1333–1339	28 (27)	6	9.1				
55	1342–1345	21.5(20.4)	6	10.5				
54	1349–1351	9 (8.3)	6	9+5				
53	1354–1355	5 (5)	—	5+				
69	1400–1403	10 (10)	8	7				
67	1407–1410	12.5(11.3)	5.5	10.2				
66	1414–1417	18.9(17)	5	10.5				
64	1424	30–(27.5)	4	12.5				
62	1436–1442	29 (27)	4	12.5				
79	1449–1500	35 (33)	4	11.5	o, Cb. —8	W–4		
78	1503–1510	35+(33)	4.5	12.5	o, Cb. —10	W–2	2–2	30.0
77	1513–1519	35 (33)	4.5	11.5				
76	1521–1529	34 (31)	4.5	11.5				
75	1533–1540	31 (29.1)	4.5	11.6	d, (1536–1541)			
73	1546–1549	19 (17.3)	5.5	9.5				
85	1559–1611	25 (23)	4.5	11.6				
91	1614–1619	20 (18.6)	5.5	8.4				
90	1623–1627	14 (13)	5.5	8.2				
88	1632–1635	10 (9.1)	6.5	7.0				
97	1650–1656	28.7(27.9)	5	9.5				
98	1701–1718	35+(35.8)	5	10.5				
99	1723–1730	29.5(28.9)	5	11.5	b, c. Nc. —5	E–2	2–2	30.0
92	1739–1748	35+(37)	4.5	12.5				
76	1757–1801	18.5(17.8)	5	11.3				
84	1806–1814	35 (32.5)	5	9.9				
83	1820–1826	35+(35.6)	4	12.5				
95	1848–1852	35+(41.6)	3.5	13.5				

Table 2. Tanabe Bay chlorinity (‰) on 5th August 1958

Station	Depth (meters)					
	0	5	10	20	30	B
1	18.93	18.89				18.91
2	18.89	18.82	18.84			18.88
4	18.80	18.83				18.85
5	18.77	18.84	18.80			18.94
6	18.44	18.82				18.85
7	18.78	18.80	18.84			19.00
9	18.77	18.80				18.85
10	18.82	18.86	18.75			19.06
11	18.80	18.84	18.86			19.06
13	18.80	18.84	18.80			18.85
15	18.80					18.82

16	18.80	18.84	18.88			19.06
18	18.80	18.84	18.86			18.94
19	18.80	18.82				18.85
20	18.80	18.75	18.80			19.09
22	18.73	18.86	18.92			19.09
23	18.71	18.86	18.69			19.00
24						18.85
25	18.71	18.82	18.95			18.91
26	18.77	18.78	18.78			18.94
28	18.75					18.79
31	18.64	18.75				18.91
32	18.66	18.73				18.88
33	18.69					18.76
35	18.53					18.85
36	18.71					18.88
48	18.73	18.89				19.00
37	18.73	18.84				18.88
38	18.69	18.82				18.94
39	18.67	18.83	18.91			19.09
46	18.82	18.86				18.97
41	18.80	18.84	18.84	19.09		19.06
43	18.82	18.80	18.85			19.18
44	18.84	18.82	18.73	19.12		—
53	18.80					18.94
54	18.78	18.84				19.00
55	18.84	18.86	18.97			19.03
56	18.84	18.89	19.18	19.00		19.09
57	18.84	18.88	18.91	19.06		19.09
59	18.75	18.89				18.91
69	18.62	18.86				19.00
67	18.71	18.84				19.00
66	18.75	18.80	18.91			19.03
64	18.80	18.80	18.97	19.03		19.12
62	18.88	18.80	18.70	19.03		19.21
60	18.84	18.82				18.94
73	18.71	—	18.76			19.00
75	18.80	18.80	18.91	19.00		19.15
76	18.82	18.80	18.97	19.00		19.09
77	18.86	18.82	18.88	19.03	19.15	19.21
79	18.84	18.89	18.82	19.00	19.12	19.24
78	18.86	18.86	18.85	19.00	19.15	19.21
85	18.75	18.88	18.91	19.06		19.21
84	18.69	18.88	18.97	19.06	19.21	19.24
83	18.80	18.89	18.91	19.06	19.15	19.27
88	18.75	18.80				19.00
90	18.66	18.88	18.85			19.06
91	18.71	18.84	18.85			19.06
97	18.80	18.84	19.00	19.09		19.24
98	18.80	18.84	18.94	19.12	19.12	19.30
99	18.88	18.84	18.97	19.15		19.18
96	18.77	18.88	18.97			19.09
92	18.86	18.89	18.91	19.12	19.12	19.30

95	18.78	18.77	18.79	18.06	19.15	19.24
T010	18.62	18.86				18.94
T 09	18.73	18.82				19.00
T 08	18.73	18.80				19.00
T 07	18.77	18.84				19.00
T 05	18.80	18.82	18.86	19.06		19.15
Sample Number	68	61	41	20	8	68
Total	1276.00	1148.86	773.88	381.13	153.16	1293.53
Average	18.76	18.83	18.88	19.06	19.15	19.02

Table 3. Tanabe Bay water temperature on 5th August 1958

Station	Depth (meters)					
	0	5	10	20	30	B
1	28.85	28.60				28.22
2	29.05	28.24	28.20			27.71
4	28.87	28.40				28.36
5	28.82	28.30	27.67			26.84
6	28.81	28.48				27.30
7	28.94	28.68	27.72			25.10
9	28.50	28.40				27.20
10	29.00	28.30	28.79			25.80
11	29.15	28.56	27.72			25.60
13	29.00	28.22	27.81			27.32
15	28.92					28.63
16	29.08	28.60	27.90			25.67
18	29.03	28.96	27.83			27.16
19	29.10	28.82				27.90
20	29.17	28.41	28.52			25.40
22	29.60	28.30	27.70			25.60
23	29.47	28.51	27.95			26.35
24	29.50					28.90
25	29.60	28.46				26.92
26	29.92	28.06	27.73			26.90
28	29.61					27.81
31	29.80	29.42				27.50
32	29.80	28.35				27.72
33	29.88					29.56
35	30.30					28.30
36	29.90					28.70
48	29.90	28.28				27.98
37	29.86	28.40				28.10
38	29.53	28.50				27.49
39	29.42	28.50	28.90			24.90
46	29.48	28.48				28.20
41	29.04	28.69	28.70	—		25.08
43	29.40	28.80	27.90			25.30
44	29.60	28.42	28.30	25.19		24.62
53	29.91					29.32
54	29.79	28.68				28.10
55	29.70	28.70	28.44			25.90

56	29.68	28.57	28.12	25.63		24.90
57	29.44	28.60	28.05	25.61		25.12
59	28.89	28.40				28.21
69	30.10	28.60				27.93
67	29.80	28.62				27.32
66	29.73	28.82	28.38			26.41
64	29.60	28.71	28.20	26.60		25.50
62	29.26	28.41	28.12	26.92		24.47
60	28.82	28.65				—
73	29.60	28.30	28.09			26.98
75	29.20	28.60	27.79	26.36		24.96
76	29.20	28.89	27.40	26.62		25.52
77	29.10	28.51	27.31	26.39	23.91	23.63
78	29.10	28.10	27.62	26.66	24.06	23.90
79	29.00	28.21	27.72	26.31	24.87	23.91
85	29.30	27.99	27.50	25.35		25.20
84	29.34	28.01	27.29	25.56	23.16	22.80
83	29.02	28.30	28.30	25.70	23.16	23.16
88	29.99	29.42				28.19
90	29.70	28.30	27.41			26.83
91	29.30	28.46	28.81			25.91
97	28.89	28.42	26.92	24.84		24.68
98	28.88	28.31	26.69	24.53	24.24	23.68
99	28.68	28.50	26.84	24.54		24.13
96	29.20	27.91	27.42			25.98
92	28.80	28.30	27.49	25.31	23.28	22.79
95	28.49	28.41	28.22	26.10	23.97	22.90
T010	30.10	28.34				28.10
T 09	29.95	28.50				27.96
T 08	29.88	28.38				27.60
T 07	29.80	28.50				27.34
T 05	29.60	28.52	28.10	25.38		25.10
Sample Number	69	62	40	19	8	68
Total	2027.09	1766.08	1115.57	489.60	190.65	1794.57
Average	29.28	28.49	27.89	25.77	23.83	26.39

Table 4. Tanabe Bay Silicate-Si (μg-atoms/L) on 5th August 1958

Station	Depth (meters)					
	0	5	10	20	30	B
1	3.05	0.38				6.86
2	2.67	0.76	3.81			11.44
4	4.58	6.48				4.58
5	3.43	5.72	6.48			19.83
6	22.89	1.91				19.45
7	2.67	2.67	7.63			18.69
9	3.05	7.63				25.93
10	4.96	1.53	4.20			8.39
11	2.29	0.38	3.43			15.25
13	3.81	0.76	6.10			11.44
15	5.34					7.63

16	2.67	1.14	3.81			15.64
18	1.53	5.47	4.58			12.21
19	3.43	3.81				16.02
20	2.67	2.29	4.20			7.63
22	1.53	3.05	6.48			11.45
23	2.29	3.43	4.58			13.73
24	—					7.63
25	1.53	0.76	3.81			11.45
26	3.43	2.29	2.67			18.31
28	3.81					10.68
31	3.05	3.05				18.31
32	4.58	1.91				11.45
33	3.81					5.72
35	4.58					8.77
36	1.91					7.63
48	1.14	0.76				3.82
37	2.67	0.38				10.30
38	1.91	0.38				13.74
39	2.67	3.05	6.48			11.06
46	0.00	0.38				4.96
41	1.14	0.76	3.81	7.63		7.63
43	0.76	3.43	4.20			6.48
44	0.00	6.48	3.05	5.34		—
53	0.38					3.82
54	0.00	0.38				4.58
55	0.38	3.05	7.25			6.10
56	0.00	3.05	4.58	4.20		5.34
57	0.00	3.05	3.81	4.20		4.58
59	1.91	3.81				6.48
69	0.38	2.67				5.34
67	0.00	1.14				6.86
66	0.76	1.53	6.86			6.86
64	0.00	1.91	3.05	3.81		3.82
62	0.00	3.43	4.58	3.05		8.77
60	3.05	6.87				6.48
73	0.38	3.05	1.53			6.86
75	0.76	3.81	4.20	3.05		11.45
76	0.00	1.91	3.05	3.81		4.20
77	0.00	1.14	3.81	2.29	3.43	11.06
79	0.00	1.53	3.05	1.91	3.43	6.10
78	0.38	3.05	8.39	2.67	4.20	4.58
85	0.76	2.29	3.81	3.05		6.48
84	1.91	1.91	2.67	3.43	3.81	4.58
83	1.10	0.76	1.14	2.29	3.81	3.05
88	0.76	3.05				8.77
90	0.00	2.67	3.81			3.82
91	0.00	1.53	4.20			4.96
97	0.00	2.29	3.81	4.20		3.05
98	0.00	3.05	3.43	2.29	3.81	3.05
99	0.00	0.38	6.86	3.43		4.96
96	0.76	3.05	2.67			3.82
92	0.38	0.38	3.81	3.05	3.81	3.43
95	0.76	3.43	3.43	3.05	2.29	4.58

T010	5.72	0.76				5.72
T 09	0.00	0.38				4.58
T 08	0.00	1.14				8.77
T 07	0.00	1.14				6.10
T 05	0.00	7.25	3.43	7.63		8.01
Sample Number	68	62	41	20	8	68
Total	129.28	151.88	176.55	74.38	38.59	585.12
Average	1.90	2.45	4.31	3.72	3.57	8.60

Table 5. Tanabe Bay Phosphate-P (μg-atoms/L) on 5th August 1958

Station	Depth (meters)					
	0	5	10	20	30	B
1	0.00	0.1037	0			0.1658
2	0.0207	0.0621	0.0207			0.1658
4	0.00	0.249				0.0621
5	0.00	0.0207	0.0829	0.0414		0.621
6	0.259	0.0207				0.456
7	0.0414	0.0207	0.0621			0.621
9	0.787	0.0829				0.787
10	0.00	0.0621	0.00			0.331
11	0.00	0.00	0.00			0.373
13	0.0414	0.0207	0.00			0.207
15	0.1037					0.1242
16	0.0414	0.00	0.331			0.580
18	0.0207	0.00	0.0207			0.269
19	0.0207	0.0414				0.663
20	0.0621	0.00	0.00			0.207
22	0.1242	0.00	0.145			0.269
23	0.0621	0.00	0.0621			0.248
24						0.0829
25	0.0207	0.00				0.248
26	0.0414	0.00	0.1242			0.663
28	0.0414					0.1865
31	0.0207	0.00				0.373
32	0.0414	0.0414				0.1865
33	0.00					0.0828
35	0.00					0.207
36	0.00					0.0414
48	0.00	0.0414				0.0414
37	0.00	0.0207				0.207
38	0.0829	0.00				0.248
39	0.0414	0.00	0.00			0.352
46	0.00	0.0414				0.0414
41	0.0414	0.0207	0.0621	0.1451		0.351
43	0.00	0.00	0.0829			0.0083
44	0.00	0.00	0.1037	0.1658		—
53	0.00	0.0414				0.00
54	0.00	0.00				0.00
55	0.00	0.0207	0.0414			0.0621
56	0.00	0.0207	—	0.1450		0.0621
57	0.00	0.00	0.0207	0.1037		0.0621

59	0.00	0.0414				0.0829
69	0.0414					0.0207
67	0.00	0.00				0.0207
66	0.0414	0.0414	0.0414			0.0207
64	0.00	0.0207	0.0207	0.0829		0.331
62	0.00	0.0414	0.1242	0.0414		0.207
60	0.00	0.0621				0.0207
73	0.00	0.0207	0.0414			0.1658
75	0.00	0.0207	0.0207	0.1037		0.0414
76	0.00	0.0414	0.0414	0.0621		0.1658
77	0.00	0.0414	0.0207	0.0621	0.1658	0.0828
79	0.00	0.0414	0.0207	0.0414	0.1242	0.0621
78	0.00	0.0414	0.00	0.0207	0.1450	0.0207
85	0.00	0.0414	0.00	0.0621		0.1805
84	0.00	0.0207	0.0414	0.1242	0.1242	0.00
83	0.00	0.00	0.0207	0.0414	0.1242	0.00
88	0.00	0.00				0.0829
90	0.00	0.00	0.0207			0.00
91	0.00	0.00	0.00			0.00
97	0.00	0.00	0.0414	0.0621		0.00
98	0.00	0.00	0.00	0.1037	0.1242	0.00
99	0.00	0.00	0.0538	0.1037		0.0207
96	0.00	0.00	0.0207			0.00
92	0.00	0.0207	0.0414	0.1037	0.1658	0.00
95	0.00	0.00	0.00	0.00	0.1037	0.00
T010	0.00	0.0829				0.0621
T 09	0.00	0.0414				0.0621
T 08	0.00	0.0207				0.248
T 07	0.00	0.0207				0.0414
T 05	0.00	0.0414	0.0621			0.248
Sample Number	68	62	39	20	8	68
Total	1.9985	1.6361	1.7929	1.6162	1.0771	11.8504
Average	0.0294	0.0263	0.0459	0.0808	0.1346	0.1742

Table 6. Tanabe Bay pH on 5th August 1958

Station	Depth (meters)					
	0	5	10	20	30	B
1	8.4	8.4				8.4
2	8.4	8.4	8.4			8.3
4	8.4	8.4				8.3
5	8.4	8.4	8.3			8.3
6	8.4	8.3				8.4
7	8.4	8.4	8.4			8.3
9	8.4	8.4				8.3
10	8.4	8.4	8.4			8.3
11	8.4	8.4	8.4			8.3
13	8.4	8.4	8.4			8.3
15	8.3					8.3
16	8.4	8.4	8.4			8.3
18	8.4	8.4	8.4			8.3

19	8.4	8.4				8.3
20						
22						
23						
24						
25						
26						
28						
31						
32						
33						
35	8.3					8.3
36						
48						
37						
38						
39						
46						
41						
43						
44						
53						
54						
55	8.4	8.4				8.3
56						
57						
59	8.4	8.4				8.4
69						
67						
66						
64						
62						
60	8.4	8.4				8.4
73						
75						
76	8.4	8.45	8.4	8.4	8.3	8.3
77						
79						
85						
84						
83						
88	8.4	8.4				8.4
90						
91						
97						
98						
99	8.4	8.4	8.4	8.4		8.3
96						
92						
95	8.4	8.4	8.4	8.4	8.3	8.3
T010						
T 09						

T 08						
T 07						
T 05						
Test Number	22	21	12	3	2	22
Average	8.4	8.4	8.4	8.4	8.3	8.3

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ON THE EXCHANGE OF WATER AND THE PRODUCTIVITY OF A BAY WITH SPECIAL REFERENCE TO TANABE BAY (III)

By
Yoshiaki Fukuo
(Geophysical Institute, Kyoto University)

Introduction

Specific gravity of sea water σ_0 at 0°C derived from Knudsen Tables by the chlorinity, is scarcely consistent with the specific gravity at 0°C of the same water σ_0' by direct measurement in our investigation.

The difference $\Delta\sigma_0 \equiv \sigma_0 - \sigma_0'$ (the accuracy of $\Delta\sigma_0$ is $\pm 10^{-2}$) may have occurred as the density of sea water is not expressible by Knudsen's formula.

The factors which give rise to $\Delta\sigma_0$ have not yet been well investigated. But, as one of them, the basic production may be accepted, because it is usually recognized that the living bodies in sea water would assimilate with part of dissolved materials in the water. However, $\Delta\sigma_0$ may decrease, probably when sea water is mixed with land water, since the Cl-ratio of the latter is greater than that of sea water. The density of the sea water which has positive $\Delta\sigma_0$ is less than that obtained by Knudsen Tables. In this sense, $\Delta\sigma_0$ may be called "mass defect".

In a previous paper the author attempted to estimate bay productivity, assuming that the mass defect depends only on consumption of the dissolved materials by living bodies assimilating (HAYAMI et al, 1958), and the following value of productivity was obtained:

$$C = 0.62 \times 10^{-5}\,\eta \ (\mathrm{g/m^3\,sec}) \qquad (1)$$

where C is the time rate of consumption in a unit volume of water and η is horizontal mixing coefficient. The method of estimation was: Assuming the mean tidal range of $\Delta\sigma_0$ obtained by observing the tidal variation in $\Delta\sigma_0$ at the bay mouth, is taken for the change of $\Delta\sigma_0$ against the longitudinal extent of the tidal excursion, horizontal gradient of the mass defect at the bay mouth is known, and in a steady state, the total amount of the flux $\eta \frac{\partial(\Delta\sigma_0)}{\partial x}$ through the bay mouth equals to the total consumptions in the bay. Putting $\eta = 10^{-5}$ (c.g.s.) in (1), we get $C = 0.62$ (g/m³sec). This value seems to be fairly large, so it is attempted in this paper to estimate the value of C by a different method.

Distribution of the Mass Defect in the Bay

Method and Result of the Observation

At twenty six stations distributed uniformly in Tanabe Bay, sea water was sampled August 10th 1957, at the surface layer and at the depths of 5, 10, 15, 20 and 25 m and the mass defect and chlorinity were determined from them. The observations were carried out from 0920 hs to 1800 hs. The position and observed time at each station are shown in Fig. 1 together with the tidal curve at Mori situating at the bay head.

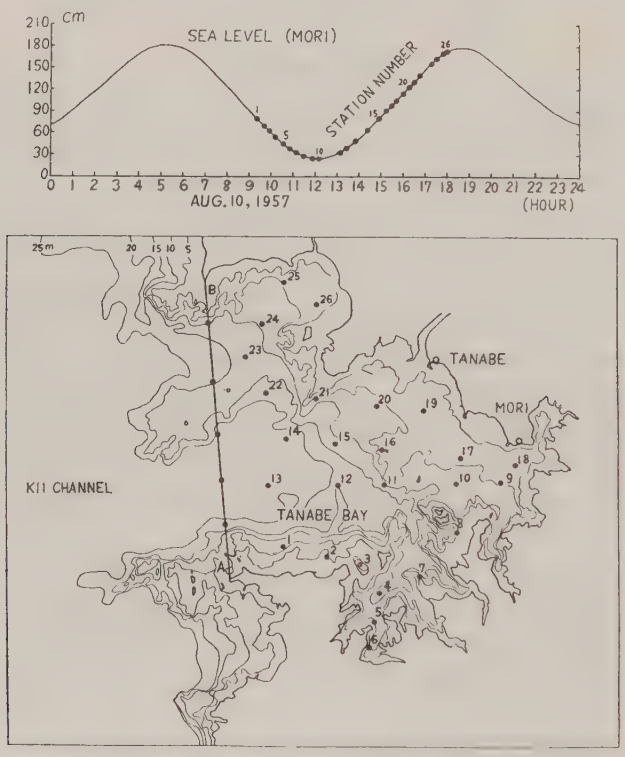

Fig. 1. Tidal variation of sea level
Location of stations and bottom topography

From 6th to 7th of August 1957, Dr. Yamazi investigated the distribution of zoo-plankton in the same bay. The numbers in Fig. 2 represent the settling volume of zoo-plankton. Plankton net was hauled in the upper 5 m layer and 50 litres of sea water passed through the net every haul.

In order to compare $\Delta\sigma_0$ distribution with zoo-plankton distribution, the mean values at 0 m and 5 m depths of Cl and $\Delta\sigma_0$ were calculated as shown in Fig. 3. The correlation diagram between mean Cl and mean $\Delta\sigma_0$ calculated is given in Fig. 4. The correlation diagram seems to indicate two groups, in

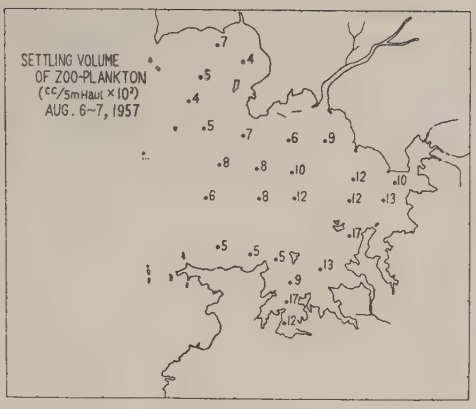

Fig. 2. Distribution of the settling volume of zoo-plankton in the upper 5 m layer

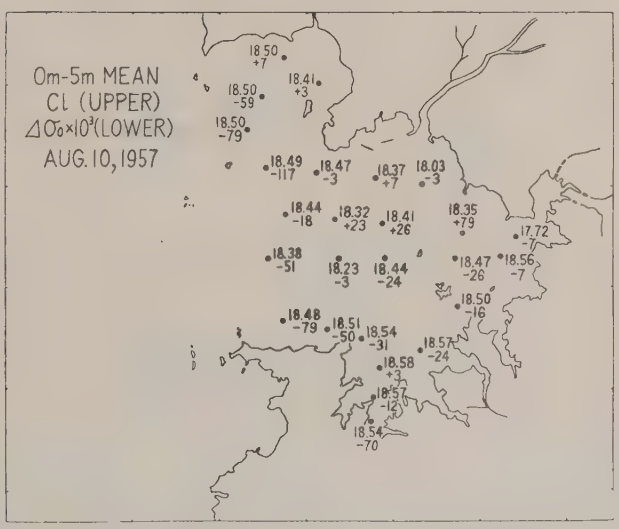

Fig. 3. Distribution of the mean values of chlorinity and mass defect at the surface and 5 m layer

one of which the chlorinity is nearly constant and the mass defect changes from –120 to 80, and in the other, the chlorinity is smaller and the mass defect is nearly zero.

The points of these two groups were represented by the symbols of inset table in Fig. 4. Using these symbols, Fig. 3 was redrawn as shown in Fig. 5.

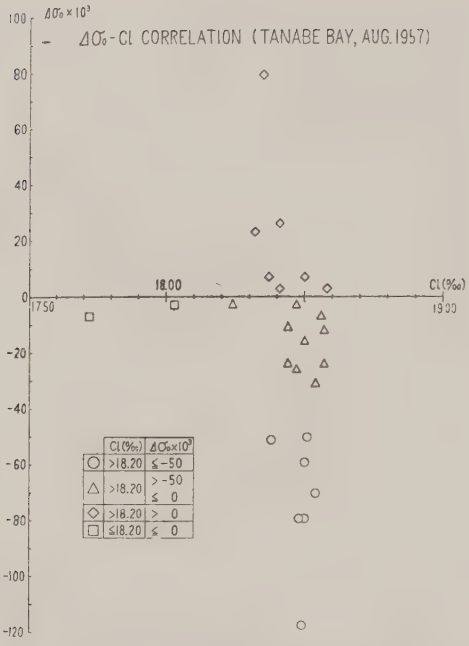

Fig. 4. Correlation diagram between the chlorinity and the mass defect

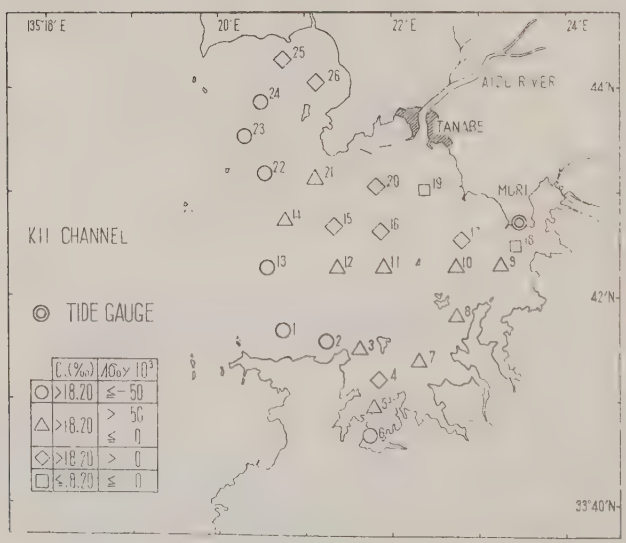

Fig. 5 Chlorinity and mass defect distribution represented by the symbols in table

Judging from the geographic positions and the values of Cl and $\Delta\sigma_0$, it may be inferred that symbol ○ indicates the open sea water; symbol ◇, the water occupied in the northern part of the bay, off the mouth of Aizu River; symbol △, the water produced by mixing of ○ with ◇; and symbol □, the water mixed with river water.

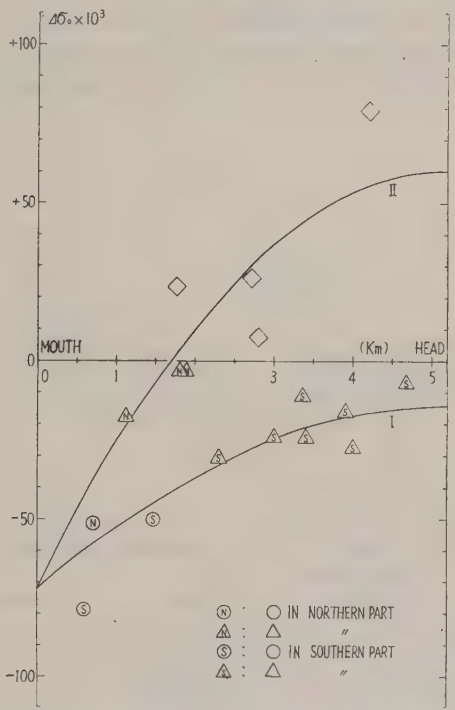

Fig. 6. Relation between the mass defect and the distance from the bay mouth line

Fig. 6, where the abscissa and ordinate represent the distance of the station from the bay mouth line, and the value of the mass defect respectively, indicates a longitudinal distribution of the mass defect. In this figure, seven stations 18, 19, 22~26 are excluded (the reason of exclusion will be seen later). All points in the southern part, except the station 4, are arranged along a curve denoted by I, and marked by "S", while all points in the northern part are arranged along a curve denoted by II, and marked by "N". We see in Fig. 6 that all points ◇ belong to curve II, while the points ○, △ belong either to the curve I or to the curve II.

From this figure it is seen that, if the rate of consumption of dissolved materials was uniform over the bay, the rate of material replenishment through the bay mouth would be greater in the southern part than in the northern part, that is, the mixing coefficient would be greater in the southern part than in

the northern part, since the gradient of curve II exceeds that of curve I, whereas if the rate of the replenishment was uniform over the bay, the consumption rate in the northern part would be in excess over that rate in the southern part.

Estimation of Productivity and its Comparison
(in the Northern and Southern Part of the Bay)

In order to make a rough estimation of the rate of consumption and the mixing coefficient quantitatively, Tanabe Bay was modelled on a rectangular bay of uniform cross section and uniform depth, and the coordinate axes were taken as in Fig. 7.

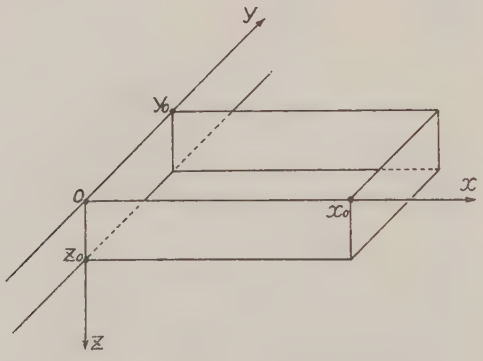

Fig. 7. Bay model and coordinate system

Diffusion equation of the mass defect under no mean current is given by

$$\frac{\partial q}{\partial t} = \eta_1 \frac{\partial^2 q}{\partial x^2} + \eta_2 \frac{\partial^2 q}{\partial y^2} + \eta_3 \frac{\partial^2 q}{\partial z^2} + c \qquad (2)$$

where η_1, η_2 are coefficients of horizontal mixing, while η_3 is that for the vertical and q, the mass defect.

Since the increment of 10^{-6} in specific gravity corresponds to addition of about 1.2 g of salt into one cubic meter of sea water, the relation between q and $\Delta\sigma_0$ is

$$q = 1.2 \times 10^3 \, \Delta\sigma_0 \quad \mathrm{g/m^3} \qquad (3)$$

Assuming that the depth of the model is 5 m and the vertical diffusion at 5 m depth not appreciable, the boundary conditions suggested are:

$$\eta_3 \frac{\partial q}{\partial z} = 0 \quad \text{at surface and bottom}$$

$$\eta_2 \frac{\partial q}{\partial y} = 0 \quad \text{at the bay side}$$

$$\eta_1 \frac{\partial q}{\partial x} = 0 \quad \text{at the bay head}$$

Integrating (2) by y and z, then

$$\frac{\partial Q}{\partial t} - \eta_1 \frac{\partial^2 Q}{\partial x^2} + \mathrm{C} \qquad (4)$$

where Q and C are the mean value of q and c respectively in a cross section of the bay.

Because the longitudinal length of the part of the bay which contains the stations 22~26 differs from the length of the main part of the bay, and the stations 18, 19 are affected by the river water, they are excluded from the model.

Supposing that the mean rate of consumption C is independent of x and the distribution of the mass defect given by Fig. 5 is stationary, the solution of equation (4) is obtained —

$$Q = Q_m + \frac{C}{2\eta}[2x_0 x - x^2] \qquad (5)$$

where Q_m is the mass defect at the bay mouth and x_0 is the longitudinal length of the main part of the bay.

Eq. (5) gives the forms of the curves I and II in Fig. 6.

Taking the mean value of seven ○ symbols as Q_m

$$Q_m = -72 \times 1.2 \quad \text{g/m}^3 \qquad (6)$$

Most plausible values of $C/2\eta$ are found by the method of the least square for the curves I and II respectively. The result is given in Table 1.

Table 1.

	$C/2\eta$ (g/m^5)
curve I (southern part)	0.26×10^{-5}
curve II (northern part)	0.59×10^{-5}

Curves I and II in Fig. 6 are drawn by these values.

The ratio of $C/2\eta$ in the southern part to that in the northern part is

$$\frac{(C/2\eta)_{\text{I}}}{(C/2\eta)_{\text{II}}} = \frac{1}{2.28} \qquad (7)$$

As to the rate C, little is known definitely, so, as a temporary measure, it is assumed that the rate C depends on the settling volume of zoo-plankton, then

$$\frac{C_{\text{I}}}{C_{\text{II}}} = \frac{P_{\text{I}}}{P_{\text{II}}} = 1.13 \qquad (8)$$

where P is the mean value of the settling volume. Then, it follows that the rate C in the southern part is roughly equal to that in the northern part. Hence, from (7) and (8), it may be considered that η_{I} is about two and half times as large as η_{II}, that is, the material replenishment through the bay mouth is about two and half times larger in the southern part than in the northern part.

Taking the mean of $C/2\eta$ in the southern and northern part, we get

$$(C/2\eta)_{\text{mean}} = 0.43 \times 10^{-5} \quad \text{g/m}^5$$

$$\text{or,} \quad C_{\text{mean}} = 0.85 \times 10^{-5}\,\eta_{\text{mean}} \quad \text{g/m}^3\,\text{sec} \qquad (9)$$

This value is in the same order of magnitude as the value of Eq. (1).

Discussions

Productivities (the rate of material consumption) from (1) and (9) are estimated under many uncertain assumptions, but the agreement in the order of magnitude of two values is interesting. In order to decide numerically the productivity by such a method, the mixing coefficient η and the relation of the mass defect with living bodies must be known.

It was assumed that Fig. 3 showed the distribution at steady state, but this assumption may be open to question. The comparison between the southern and northern parts seems to turn into a comparison between ebb and flood tides, since most symbols along curve I in the southern part are sampled during ebb tide, whereas all the symbols along curve II in the northern part are sampled during flood tide. It is desirable to make simultaneous observations.

Variations in the Chlorinity and Mass Defect at the Bay Head

The Method of Investigation

From 23rd to 29th of August 1957, the chlorinity and mass defect were investigated on the survey lines I, II and III taken through the bay head as shown in Fig. 8.

Fig. 8. Location of the survey lines near the bay head

The water samples from the depth of about 50 cm below the surface were collected hourly between 0700 hs and 1800 hs every day at two, five and two sampling points occupied on the lines I, II and III respectively, and then, each sample of equal volume was mixed for each survey line, thus giving three mean samples for three survey lines. They represent the mean surface water along the lines I, II and III at the central epoch of their traverses. It took about

2 min., 8 min. and 3 min. to traverse the lines I, II and III respectively. The chlorinity and mass defect of these mean water samples were determined. The result is given in Fig. 9.

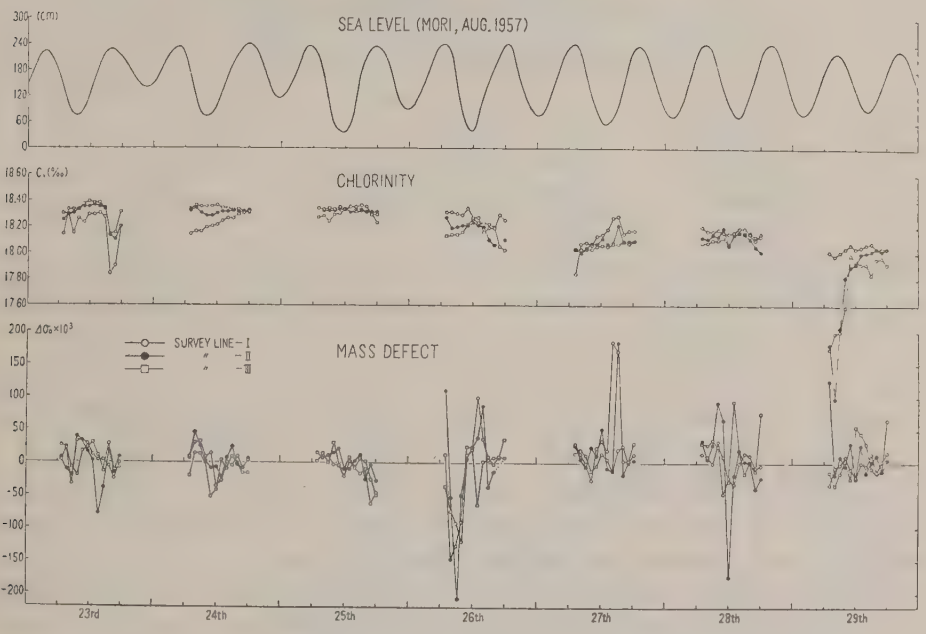

Fig. 9. Variations in sea level, chlorinity and mass defect

Some Considerations on the Result

Though the daily variations in Cl and $\Delta\sigma_0$ are cumbersome as seen in Fig. 8, the chlorinity decreased gradually from the 26th and the range of the mass defect variation suddenly became larger since the 26th.

This change of $\Delta\sigma_0$ seems to have returned to the normal state on 29th. This abnormal phenomenon may be due to the typhoon.

According to Geophysical Review No. 696 (Aug. 1957, The Japan Meteo. Agency), Typhoon No. 9 struck the shore of Kōchi Prefecture at 0300 hs on 24th August 1957 and passed through Kinki District before noon on 24th. This typhoon brought 50 mm to 300 mm of rain from 23rd to 24th on various parts of Shikoku including Kōchi. Table 2 gives the rainfall and wind data.

The gradual decrease of the chlorinity may suggest that the sea water in Tanabe Bay was mixed, probably by tidal mixing, with the sea water, the chlorinity of which was lowered under the influence of a sudden increase of the river discharge in Shikoku, along the western coast of Kii-Channel.

Judging from the fact that the typhoon passed through Kinki District on 24th, it is inferred that it took about 2 days before the effects of the typhoon were felt in Tanabe Bay.

Table 2. Total Rainfall and Maximum Wind Velocity due to Typhoon No. 9, (Aug. 1957)

Prefecture	Station	Total Rainfall (mm)	Maximum Wind Velocity		
			Magnitude (m/s)	Direction	Date (August) d. h. m.
Tokushima	Tokushima	84.6	10.8	ENE	23-21-40
	Anabuki	84.5	5.5	NE	24-11-00
	Kenzan	75.6	10.8	SSE	23-21-50
	Kawakami	268			
	Kawanishi	210			
	Sakashū	190			
	Hinotani	180			
	Shishikui	150			
Kōchi	Kōchi	94.6	5.0	W	24-04-23
	Murotomisaki	56.6	11.5	W	24-06-37
Wakayama	Shionomisaki	33.3	12.0	SW	24-10-29
	Wakayama	12.8	8.4	S	24-08-30

Investigation by Dr. Yamazi showed that the population of planktons in Tanabe Bay was subject to the great influence of this typhoon and changed abruptly in both species and number (YAMAZI, 1959).

If this evidence was associated with a sudden change of the mass defect after 26th, an interesting fact that a growth of planktons makes $\Delta\sigma_t$ increase may be supported as previously stated in the introduction.

Acknowledgement

The writer wishes to express his sincere appreciation to Prof. S. Hayami for his kind guidance and encouragement to pursue this work.

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PELECYPOD SHELL REMAINS IN TANABE BAY, WAKAYAMA PREFECTURE

By
Tadashige Habe
(Amakusa Marine Biological Laboratory, Kyushu University)

The biological survey of Tanabe Bay was made on 8th and 9th, September 1958, concerning 78 stations shown in the Figure 1. This is the first report

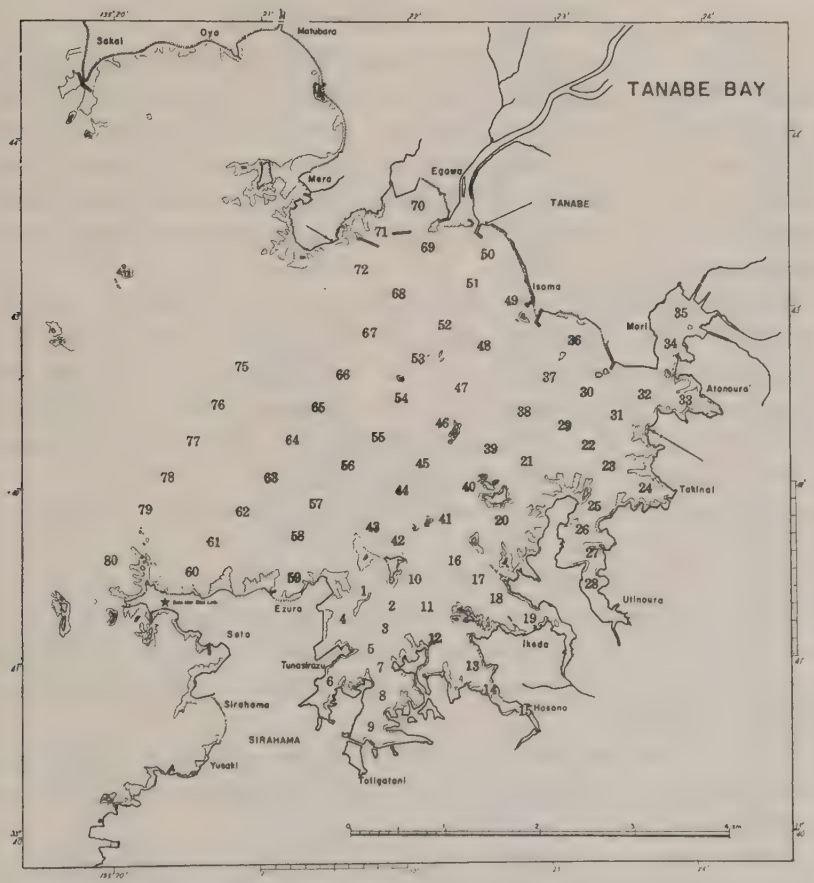

Fig. 1. Map of Tanabe Bay showing stations

on the results of this survey, in which the pelecypod shell remains are dealt with.

The samples were collected twice at each station by Ekman's bottom sampler modified by Dr. D. Miyadi which covers the area of one fiftieth square meter and were sifted out by the sieve of one square millimeter, and the materials were examined.

The hydrographic conditions of 78 stations are shown in Table 1. The depth of water varies from 5.0 m. (St. 33) to 36 m. (St. 78), and gradually increases to the entrance from the bay bottom. The bottom is covered by mud or fine sandy mud for the most part of bay, but sand and gravel distribute the areas near the submarine reefs. The bottom temperature ranges from 26.0°C (St. 78) to 29.1°C (St. 36), usually decreasing 0.5°C for 5 m. in depth from 5 m. to 36 m.

Before going further the writer expresses his thanks to the members of the Seto Marine Biological Laboratory for their cooperations.

Remains of Pelecypod Shells

The remains of pelecypod shells collected with the bottom sampler from 77 stations are composed of about 195 species listed in the Table 2. Of them 11 species are new to science and scientific names of several species are still indeterminable. The stations described by thick letter in the Table 2, show that the number of shell remains of the named species occupied more than 10% of the number of shell remains of all pelecypod species collected from the stations described by thick letter.

The median number of the pelecypod species of each station is 18 and the largest number of the pelecypod species from one station is 66 at St. 57. The stations, species number of which is less than median number, distribute in the central area of clay mud and in the northeast area of fine sandy mud. While the stations in the southeast area and near the submarine reefs have the number of species exceeded the median number.

The dominant species in the shell remains are the following 11 species which are found in more than 38 stations.

1. *Fulvia hungerfordi* appeared in 69 stations of 77 stations and the number of valve of this species is many in the bay bottom rather than the entrace.
2. *Theora lubrica* was collected at 67 stations and this is a representative species of strong embayment area usually together with *Fulvia hunferfordi* and *Paphia undulata*.
3. *Microcirce dilecta* was present in 56 stations and the number of valve of this species decreases to the bay bottom from the entrance as a characteristic species of weak embayment degree.
4. *Pillucina neglecta* is an undescribed species, but is very common in bays along the Pacific coast of the southern Japan. This was gathered in 47 stations.

5. *Alvenius ojianus* is a representative of middle embayment degree. This species is found in 45 stations, but the valves are very small in number in each station.
6. *Fabulina minuta* is gathered in 44 stations from the bottom of fine sand.
7. *Modiolus nipponica* which attached on the rocks by the byssus, was spread in 44 stations near the submarine reefs.
8. *Dosinia angulosa* is a common species on the muddy bottom of bays, but the valves of this species are usually small in number.
9. *Paphia undulata* is the characteristic species of strong embayment area, and was found in 40 stations of the inner area of this bay.
10. *Macoma awajiensis* is rather common in bays but usually small in number. This was collected at 40 stations in the inner area of this bay.
11. *Nucula paulula* is an indicator of the weak embayment degree, but rather chiefly spread in 39 stations of the outer half of this bay.

Table 1. Some hydrographic observations in Tanabe Bay
(Sept. 8–9th, 1958)

Station number	Depth in meters	Bottom temperature (°C)	Bottom nature
1	7.4	29.0	c.S.M.
	7.4	29.0	S.M.
2	16.0	27.6	M.
	17.0	27.5	M.
3	15.5	27.7	M.
	14.5	27.8	f.S.M.
4	11.0	28.1	S.M.
	11.0	28.1	S.M.
5	15.5	28.0	M.
	18.0	27.8	f.S.M.
6	8.8	28.0	f.S.M.
	9.5	28.0	f.S.M.
7	17.0	27.7	M.
	17.0	27.7	M.
8	16.5	27.7	M.
	16.0	27.7	M.
9	14.0	27.9	f.S.M.
	13.5	—	f.S.M.
10	20.0	27.0	M.
	20.0	27.0	M.
11	20.0	27.1	M.
	17.0	27.2	S.M.
12	17.0	27.5	f.S.M.
	17.0	27.4	f.S.M.
13	15.0	27.8	M.
	15.5	27.8	M.
14	12.8	28.0	S.M.
	13.0	28.0	S.M.
15	5.5	28.7	S.M.
	5.5	28.7	S.M.

Station number	Depth in meters	Bottom temperature (°C)	Bottom nature
16	23.0	27.0	M.
	23.5	27.1	M.
17	20.0	27.3	M.
	20.5	27.3	M.
18	16.5	27.9	M.
	16.0	27.9	M.
19	12.3	28.4	f.S.M.
	11.5	28.4	f.S.M.
20	22.0	27.3	M.
	24.5	27.4	M.
21	17.0	27.4	M.
	17.5	27.4	M.
22	17.5	27.3	M.
	17.3	27.4	M.
23	16.8	27.5	M.
	16.7	27.5	M.
24	7.1	28.5	M.
	6.3	28.7	M.
25	15.9	27.5	M.
	16.0	27.6	M.
26	16.0	27.5	M.
	16.1	27.5	M.
27	13.5	27.8	M.
	13.7	27.8	M.
28	6.1	28.7	M.
	6.2	28.7	M.
29	14.8	28.0	M.
	14.9	27.8	M.
30	10.2	28.4	M.
	10.1	28.5	M.
31	12.0	28.0	M.
	12.0	28.0	M.
32	11.2	28.1	M.
	11.1	28.0	M.
33	5.0	29.0	S.M.
	5.1	29.0	S.M.
34	9.7	28.2	f.S.M.
	10.2	28.2	f.S.M.
35	6.1	28.7	M.
	6.9	28.7	M.
36	6.5	28.9	f.S.M.
	5.5	29.1	f.S.M.
37	16.5	28.1	M.
	16.5	28.2	M.
38	15.0	27.8	M.
	15.1	27.8	M.
39	17.2	27.3	M.
	18.0	27.3	M.
40	25.0	27.0	M.
	25.0	27.0	M.
41	27.0	27.0	M.
	27.0	27.0	M.

Station number	Depth in meters	Bottom temperature (°C)	Bottom nature
42	24.0	27.4	M.
	27.0	27.3	M.
43	25.0	27.6	Sh.M.
	21.0	—	M.
44	15.9	28.2	f.S.M.
	17.3	28.1	f.S.M.
45	31.5	27.0	M.
	32.0	27.0	M.
46	18.0	27.8	M.
	18.1	27.8	M.
47	13.0	28.0	M.
	13.1	28.0	M.
48	9.5	28.6	f.S.
	9.5	28.6	f.S.
49	8.1	28.8	f.S.
	8.1	28.8	f.S.
50	7.7	28.2	f.S.M.
	7.7	28.2	f.S.M.
51	9.0	28.1	f.S.M.
	9.0	28.1	f.S.M.
52	10.5	28.0	f.S.M.
	10.5	28.0	f.S.M.
53	12.0	27.8	M.
	12.1	27.8	M.
54	12.8	—	S.Sh.
	12.8	—	S.Sh.
55	28.5	26.8	M.
	28.5	26.8	M.
56	28.3	26.8	M.
	28.5	26.9	M.
57	24.0	27.4	f.S.M.
	24.0	27.4	f.S.M.
58	13.0	28.2	f.S.
	13.0	28.2	f.S.
59	6.9	28.5	f.S.
	6.5	28.5	f.S.
60	8.0	28.2	f.S.
	8.0	28.2	f.S.
61	15.5	28.0	f.S.
	15.5	28.0	f.S.
62	26.0	27.0	f.S.M.
	26.0	27.0	f.S.M.
63	29.5	26.7	f.S.M.
	29.0	26.8	f.S.M.
64	30.5	26.5	M.
	30.2	26.6	M.
65	29.9	26.7	M.
	30.0	26.7	M.
66	19.2	27.8	f.S.M.
	19.2	27.8	f.S.M.
67	13.3	27.9	f.S.M.
	13.5	28.0	f.S.M.

Station number	Depth in meters	Bottom temperature (°C)	Bottom nature
68	11.5	27.9	f.S.M.
	11.5	27.9	f.S.M.
69	9.1	28.1	M.
	9.1	28.1	M.
70	6.0	28.8	f.S.M.
	6.0	28.8	f.S.M.
71	10.0	28.0	M.
	10.0	28.0	M.
75	28.5	—	G.Sh.
	29.0	—	G.Sh.
76	32.0	26.4	M.
	32.0	26.4	M.
77	32.0	27.0	f.S.M.
	33.0	27.0	Sh.
78	36.0	26.0	M.
	36.0	26.0	M.
79	29.0	26.8	S.
	29.0	—	G.
80	24.0	—	G.
	24.0	—	Sh.

Table 2. List of the bivalves deposited on the bottom in Tanabe Bay (Sept. 8–9th, 1958)

Specific name	Station Number
1. *Solemya* (*Acharax*) *japonica* Dunker	59ab.
2. *Nucula paulula* A. Adams	1b, 2b, 3b, 4a, 5ab, 10a, 11ab, 12a, 14b, 16ab, 18a, 19b, 20ab, 25a, 29a, 33a, 36a, 41a, 42ab, 43ab, 44ab, 46b, 47b, 53ab, 57ab, 58a, 59a, 60a, 61a, 62ab, 63ab, 64ab, 66a, 67a, 68ab, 75b, 76a, 77ab, 79b.
3. *Ennucula niponica* (Smith)	16b, 25a, 40a, 77ab.
4. *Saccella sematensis* (Suzuki et Isizuka)	68ab.
5. *Cucullaea granulosa* Jonas	77b.
6. *Arca navicularis* Bruguiére	41a, 43b, 47b, 57a, 60a.
7. *Arca boucardi* Jousseaume	1a, 2b, 3a, 7a, 8a, 11b, 12a, 16b, 41a, 42a, 43a, 44a, 53ab, 54a, 57b, 77b.
8. *Barbatia* (*Barbatia*) *lima* (Reeve)	11b, 12b, 20a, 39a, 43ab, 44a, 47a, 53b, 57a, 58a, 79ab.
9. *Barbatia* (*Savignyarca*) *obtusoides* (Nyst)	2b, 3ab, 4ab, 7a, 13a, 14ab, 19ab, 20a, 25a, 32b, 33ab, 35ab, 36a, 41a, 42a, 45b, 53ab, 57b, 58a, 71b.
10. *Barbatia* (*Ustularca*) *bicolorata* (Dillwyn)	79b.
11. *Barbatia* (*Ustularca*) *stearnsi* (Pilsbry)	1ab, 3a, 4a, 7b, 11b, 12a, 18b, 20a, 21b, 25b, 40a, 41a, 42a, 43ab, 44a, 47ab, 49a, 53ab, 54b, 57b, 58ab, 62a, 67b, 79ab.

12. *Acar plicata* (Dillwyn)	1b, 3a, 4b, 5b, 11b, 12a, 16a, 20a, 36a, 41a, 42a, 43ab, 44a, 47b, 53ab, 54ab, 57b, 64a, 75b, 77b, 79b.
13. *Anabara* (*Diluvarca*) *tricenicosta* (Nyst)	44b, 57a, 64b, 77ab.
14. *Anabara* (*Scapharca*) *broughtonii* (Schrenck)	3b, 18b, 25a, 40a, 49b.
15. *Striarca* (*Galactella*) *symmetrica* (Reeve)	1ab, 2ab, 3ab, 4ab, 5ab, 6ab, 7a, 8a, 9b, **11ab**, **12a**, 14ab, 16b, 19b, 20ab, 23b, 25ab, 31a, 33ab, 41a, 42ab, **43ab**, 44a, 46a, 47ab, 53ab, **54ab**, 57ab, 61ab, 71b, 75b.
16. *Striarca* (*Spinearca*) *interplicata* (Grabau et King)	7b, 16ab, 22b, 35b, 39a, 47b, 62ab, 63b, 76a.
17. *Oblimopa forskalii* (A. Adams)	57a, 77a, 79b.
18. *Modiolus nipponica* (Oyama)	1ab, 2b, 3b, 4b, 5ab, 6a, 7ab, 8a, 9ab, 10a, 11ab, 12ab, 14ab, 15b, 16ab, 20ab, 21b, 22b, 25ab, 27b, 28ab, 31b, 33a, 34a, 36a, 39ab, 40a, 41a, 42ab, 43ab, 44a, 46ab, 47ab, 50b, 52b, 53ab, 56b, 57ab, 58ab, 62b, 63ab, 64ab, 68a, 77ab.
19. *Musculus* (*Musculista*) *senhousia* (Benson)	1b, 2ab, 3ab, 5ab, 6a 7a, 8a, 9ab, 11b, 13ab, 14ab, 20a, 23a, 25a, 32b.
20. *Musculus* (*Musculista*) *japonica* (Dunker)	33a, 34ab, 35a, 36b, 37a, 39b, 40b, 47ab, 49a, 70b.
21. *Hormomya mutabilis* (Gould)	1b, 4a, 5a, 14b, 36a, 43b, 57a.
22. *Trichomya hirsuta* (Lamarck)	57a.
23. *Septifer* (*Septifer*) *bilocularis* (Linné)	4b, 25b.
24. *Septifer* (*Mytilisepta*) *virgatus* (Wiegmann)	11b, 44a.
25. *Septifer* (*Mytilisepta*) *keenae* Nomura	2b, 3a.
26. *Mytilus edulis* Linné	25a.
27. *Musculus* (*Modiolarca*) *neglectus* Kuroda	16a, 43b, 44a, 46b, 47ab, 63a, 64ab, 79ab.
28. *Musculus quadrula* (Gould)	2ab, 3ab, 4ab, 5b, 9a, 11b, 12ab, 20ab, 25ab, 35a, 41a, 42a, 43ab, 44ab, 47b, 49b, 52a, 57ab, 58ab, 60a, 61ab, 62b, 63b, 68b, 77b.
29. *Botulina coralliophaga* (Gmelin)	25a, 53b.
30. *Trichomusculus semigranatus* (Reeve)	1b, 2a, 3ab, 11b, 20a, 41a, 42ab, 43ab, 44ab, 46b, 53ab, 57ab, 58b, 59b, 61ab, 64b, 68a, 79.
31. *Adula atrata* (Lischke)	2a, 3b, 4ab, 5b, 6ab, 7ab, 8b, 9ab, 11a, 13ab, 14ab, 16b, 18b, 19ab, 25ab, 32b, 33ab, 34a, 35ab, 36a, 37b, 42a, 43b, 48b, 49a, 70a, **71ab**, 79a.
32. *Isognomon legumen* (Gmelin)	53b.
33. *Malleus* (*Parimalleus*) *irregularis* (Jousseaume)	3b, 4a, 11b, 40a, 41a, 44a, 53b, **54a**, 79ab.
34. *Pinctada martensi* (Dunker)	1ab, 2a, 4b, 7b, 9a, 11b, 14a, 20a, 35a, 39a, 43a, 44a, 47ab, 53b, 57a, 58a, **70b**, 71b, 75b.
35. *Pinna* (*Cyrtopinna*) *attenuata* Reeve	70b.
36. *Dimya radiata* Kuroda	75b.

37. *Plicatula australis* Lamarck — 1b, 4a, 11b, 25a, 31a, 41a, 42ab, 43a, 44ab, 47a, 53ab, 54a, 57ab, 64a, 71b, 75b, 77b, 79b, 80.

38. *Chlamys irregularis* (Sowerby) — 4b, 6a, 7a, 8b, 10a, 11b, 12a, 14b, 22b, 25ab, 34a, 41a, 42ab, 44a, 53a, 58b, 64b, 75a, 77ab.

39. *Chlamys nipponensis* Kuroda — 57b.

40. *Chlamys* (*Mimachlamys*) *nobilis* (Reeve) — 47b.

41. *Decatopecten striatus* (Schumacher) — 25b, 47a, 57a, 77b.

42. *Excellichlamys spectabilis* (Reeve) — 41a, 57b.

43. *Pecten* (*Notovola*) *albicans* (Schröter) — 3a, 4a, 5b, 6b, 9b, 12b, 13b, 14ab, 25a, 41a, 42a, 43b, 44a, 47ab, 53b, 57ab, 63a, 77ab.

44. *Spondylus barbatus* Reeve — 1b, 2b, 4b, 5b, 11ab, 12a, 14b, 20a, 43ab, 44a, 53ab, 71b, 79ab.

45. *Limatula kurodai* Oyama — 20a, 47a, 77b.

46. *Limatula nippona* Habe (sp. nov.) — 44a, 47b.

47. *Lima sowerbyi* Deshayes — 2a, 3b, 12b, 20a, 40a, 41a, 44a, 53a, 79.

48. *Ctenoides japonica* (Dunker) — 4ab, 5b, 7b, 10a, 11b, 12a, 20ab, 25a, 27b, 39b, 41a, 42ab, 43a, 44ab, 47b, 53ab, 56b, 57ab, 60a, 61b, 64ab, 77ab, 79a.

49. *Promantellum hirasei* (Pilsbry) — 58b, 75b.

50. *Promantellum orientale* (Adams et Reeve) — 1b, 2b, 3ab, 4a, 5a, 7b, 8b, 10a, 11b, 12b, 14b, 20a, 22b, 34a, 36a, 39a, 42ab, 43ab, 46b, 47b, 53b, 57ab, 63a, 77ab.

51. *Promantellum amakusaensis* Habe (sp. nov.) — 7a, 8b, 12a, 20a, 42a, 53a, 57ab, 58a, 77ab.

52. *Monia umbonata* (Gould) — 31b, 44a, 53a, 79.

53. *Saxostrea echinata* (Quoy et Gaimard) — 3a, 9a, 11b, 44a, 79b.

54. "*Ostrea*" spp. — 4ab, 7a, 9a, 11ab, 12ab, 14ab, 15b, 18a, 25a, 28a, 33a, 34ab, 35ab, 39b, 42a, 43a, 47b, 59b, 64a, 70b, 71b, 80b.

55. *Ostrea* (*Crassostraea*) *gigas* Thunberg — 2b, 5a, 6a, 7a, 9b, 14b, 15b, 19a, 23a, 25b, 32b, 33a, 34a.

56. *Ostrea sedea setoensis* Habe — 11b, 36b, 43a, 54a.

57. *Crassatellites* (*Crassatellites*) *nanus* (A. Adams et Reeve) — 44a, 57b, 58a, 64a, 68a, 75a, 77ab.

58. *Cardita leana* Dunker — 1b, 2ab, 3ab, 5ab, 9b, 11ab, 12ab, 14a, 16ab, 19ab, 20a, 32b, 33ab, 35a, 40a, 41a, 42b, 43b, 44ab, 53ab, 57a, 58a, 61a, 63a, 68ab, 78a, 79ab.

59. *Carditella toneana* (Yokoyama) — 77a, 79b, 80.

60. *Alvenius ojianus* (Yokoyama) — 2b, 3ab, 4ab, 5ab, 6b, 7b, 8a, 9a, 10a, 11ab, 12a, 13b, 14a, 16ab, 18a, 20a, 23b, 25a, 32b, 34a, 39b, 40ab, 42a, 43a, 45ab, 46a, 47b, 48b, 51ab, 52ab, 53ab, 56a, 57ab, 61b, 62b, 63ab, 64a, 65a, 66ab, 67ab, 68ab, 71a, 76b, 77a, 78a.

61. *Trapezium* (*Neotrapezium*) *liratum* (Reeve) — 14b, 25b.

62. *Coralliophaga coralliophaga* (Gmelin) — 53a, 75a, 77b.

63. *Anisodonta* (*Fulcrella*) *gouldi* (A. Adams) — 42a, 77b.

64. *Joannisiella cumingii* (Hanley) — 53b.

65. *Joannisiella lunaris* (Yokoyama) — 20a, 77b.

66. *Joannisiella tsuchii* Yamamoto et Habe — 63a, 66a, 77ab.

67. *Thyasira* (*Maorithyas*) *miyadii* Habe — 77b.

68. *Leptaxinus rotundata* (Yokoyama) — 2b, 3b, 7ab, 9b, 11b, 20ab, 43a, 44a, 55b, 57ab, 62ab, 63ab, 64b, **65a**, 66a, 67a, 76b, 77ab.

69. *Lucina stearnsiana* Oyama — 2b, 13a, 47a.

70. *Ctena divergens* (Philippi) — 3a, 12a, 16a, 25a, 41a, 43b, 44a, 47b, 57ab, 58b, 79.

71. *Pillucina pisidium* (Dunker) — **1ab**, 2ab, **3ab**, **4ab**, 5ab, **6ab**, 7ab, 8ab, 9ab, 11b, 12ab, 13ab, **14ab**, **15ab**, 18b, **19ab**, 20a, 25ab, 28ab, **30a**, **33ab**, **34a**, **35ab**, 37a, 41a, 42a, 43ab, 49ab, 53b, 57ab, 58ab, **59ab**, **60ab**, 61b, 65a, 69b, 79ab.

72. *Pillucina neglecta* Habe (sp. nov.) — 1b, 2ab, 3ab, 4a, 5b, 7ab, 8ab, 9ab, 10a, 11ab, 12ab, 13b, 14ab, 16ab, 17ab, 18b, 19ab, 20ab, 21ab, 23a, 24a, 25ab, 27b, 32ab, 34a, 36a, 38ab, 39ab, 42a, 43ab, 44ab, 46ab, 47ab, 48b, **52ab**, 53a, 56b, 57ab, 61ab, 62ab, 63ab, 64a, 65a, 66b, **67a**, **68ab**, 77ab.

73. *Pillucina* (*Sydlorina*) *yamakawai* (Yokoyama) — 16a, 17a, 20a, 44a, 53a, 57a, 62ab, 63ab, 64b, 77ab, 78b.

74. *Wallucina lamyi* Chavan — 58b, 61b.

75. *Lasaea undulata* (Gould) — 1ab, 2ab, 3ab, 4ab, 5b, 6ab, 7ab, 8b, 9a, 13b, 14ab, **15ab**, 16a, **19ab**, 25ab, 33a, 43ab, 48b, 53a, 61b, 62b, 67a, 68ab, 79b.

76. *Kellia minutissima* Habe (sp. nov.) — 2a, 3ab, 5ab, 6a, 9b, 14b, 20ab, 25a, 39a, 40a, 41a, 42a, 43b, 44b, 46a, 50a, 53a, 57ab, 77ab, 79ab.

77. *Kellia* sp. — 4a, 14a, 43a, 47b, 53ab.

78. *Kellia* sp. — 77b.

79. *Fronsella fujitaniana* (Yokoyama) — 1b, 2ab, 3ab, 4a, 5ab, 6ab, 7ab, 8ab, 9ab, 10ab, 11a, 12ab, 13a, 14ab, 16a, 17ab, 18b, 19ab, 20a, 21a, 22a, 24a, 25b, 31b, 43b, 44a, 46a, 47ab, 57a, 59b, 63a, 66b, 67a, 76a.

80. *Fronsella tanabensis* Habe (sp. nov.) — 6ab, 9b, 14a, 16b, 19b, 20b.

81. *Platomysia rugata* Habe — 62a, 67b.

82. *Callomysia matsuii* Habe — 77ab.

83. *Byssobornia striatissima* (Sowerby) — 1a, 3b, 4a, 11b, 53a.

84. *Borniopsis tsurumaru* Habe — 11b, 13a.

85. *Melliteryx puncticulata* (Yokoyama) — 3b, 79.

86. *Montacutona tanakai* Habe — 12b, 19b, 20a, 25a, 31b, 32b.

87. *Mysella tanabensis* Habe (sp. nov.) — 57b.

88. *Montacutona crassa* Yokoyama — 79b.

89. *Montacutona nipponica* Yokoyama — 61a.
90. *Curvemysella paula* A. Adams — 53a.
91. *Nipponomysella oblongata* (Yokoyama) — 2a, 3b, 5b, 19a, 38a, 57a, 63a, 79b.
92. *Nipponomysella obesa* Habe (sp. nov.) — 25a, 47a, 53a, 57b, 58b.
93. *Galeommella utinomii* Habe — 2ab, 3a, 4a, 11b, 19ab, 20a, 43b, 57a, 79.
94. *Paraborniola matsumotoi* Habe — 25a.
95. *Scintilla* sp. — 9a, 14a, 19a, 25a, 48b, 53b, 57a, 58b.
96. *Chama reflexa* Reeve — 3b, 4b, 14a, 15b, 25ab, 35a, 41a, 42a, 53a, 44ab, 46a, 53ab, 54a, 57ab, 64a, 68a, 75b, 77ab.
97. *Vasticardium arenicola* (Reeve) — 11ab, 16a, 57a.
98. *Vasticardium enode* (Sowerby) — 11b.
99. *Fragum* (*Fragum*) *bannoi* Otuka — 1b, 4ab, 6a, 14ab, 15ab, 19a, 33b.
100. *Afrocardium ebaranum* (Yokoyama) — 12b, 20a, 42a, 57ab, 77b.
101. *Laevicardium undatopictum* (Pilsbry) — 11b, 20a, 25b, 40a, 43b, 44a, 48b, 57ab, 58ab, 61b, 62ab, 63ab, 70a, 77ab, 79.
102. *Fulvia mutica* (Reeve) — 1b, 3ab, 4ab, 6a, 7a, 11b, 14ab, 16b, 19b, 20a, 23a, 25b, 33a, 57b, 62b.
103. *Fulvia hungerfordi* (Sowerby) — 1ab, **2ab**, **3ab**, **4ab**, **5ab**, **6ab**, **7ab**, **8ab**, **9ab**, **10ab**, **11ab**, **12ab**, **13ab**, **14ab**, 15ab, **16ab**, **17ab**, **18ab**, **19ab**, **20ab**, **21ab**, **22ab**, **23ab**, **24a**, **25ab**, **26ab**, **27ab**, **28ab**, **29ab**, **30ab**, **31ab**, **32ab**, **33ab**, **34ab**, **35ab**, **36ab**, **37ab**, **38ab**, **39ab**, **40ab**, **41ab**, **42ab**, **43ab**, **44a**, **45ab**, **46ab**, **47ab**, **48b**, **49ab**, **50b**, **51ab**, **52ab**, **53ab**, 55ab, **56ab**, 57ab, 61b, 62ab, 63ab, 64ab, **66ab**, 67ab, 68ab, **69ab**, **70ab**, 71ab, 76ab, 77a, 78a.
104. *Circe* (*Circe*) *scripta* (Linné) — 3b, 6a, 40b, 47a, 60a.
105. *Circe* (*Redicirce*) *sulcata* Gray — 3ab, 4ab, 8b, 12a, 14b, 19a, 57b, 58ab, 59b, 60ab.
106. *Microcirce dilecta* (Gould) — 1b, 2ab, 3ab, 4ab, 5ab, 6ab, 7ab, 8ab, 9ab, 10a, 11ab, **12ab**, 13ab, 14ab, **16ab**, 17a, 18ab, 19b, **20ab**, 21ab, 25ab, 26a, 27b, 30b, 32b, 33b, 37ab, 40ab, **41a**, **42ab**, **43ab**, **44ab**, 46ab, 47ab, 48b, 49a, 51b, 53ab, 55b, **56ab**, **57ab**, 59b, 60a, 61ab, **62ab**, **63ab**, **64ab**, **65ab**, **66ab**, **67a**, **68ab**, 75b, **76ab**, **77ab**, **78ab**, **79a**.
107. *Crenocirce picta* Habe (sp. nov.) — 79.
108. *Pitar* (*Pitarina*) *lineolatum* (Sowerby) — 1ab, 2b, 4a, 6ab, 7b, 8ab, 9a, 11ab, 12b, 14a, 20a, 25ab, 33ab, 37a, 41a, 42a, 43a, 47a, 53ab, 57a, 58a, 60b, 62b, 63ab, 66b.
109. *Pitar* (*Pitarina*) *affine* (Gmelin) — 75b, 77b.
110. *Pitar* (*Pitarina*) *sulfureum* Pilsbry — 3b, 15b, 33b.
112. *Pitar* (*Costellipitar*) *chordatum* (Römer) — 3a, 63b, 77b.
113. *Callista* (*Callista*) *chinensis* (Holten) — 3b, **16a**, 18b, 47a, **48b**, 49ab, 51a, 53b, 57ab, 58b, 60ab, 61ab, 62ab, 66a, 67a, **68ab**, 70b, **77ab**, **79b**.

114. *Dosinia* (*Dosinella*) *angulosa* (Philippi)	1b, 3ab, 4b, 5b, 6ab, 7ab, 8ab, 9b, 10b, 13ab, 14ab, 15b, 16ab, 17a, 19b, 21b, 25a, 28a, 30ab, 32ab, 33a, 34b, 35b, 37b, 40b, 43ab, **45a**, 46a, 47a, 48b, 49ab, **50ab**, **51ab**, 52ab, 53a, 68a, 69ab, 70ab, 71b, 76b.
115. *Dosinia* (*Phacosoma*) *japonica* (Reeve)	3b, 9a.
116. *Dosinia iwakawai* Oyama	77b.
117. *Tigammona fischeri* (Récluz)	75a.
118. *Leucoma marica* (Linné)	53b.
119. *Leucoma laevicostata* Kuroda	79.
120. *Veremolpa minuta* (Yokoyama)	41a, 44b, 57ab, 62ab, 63ab, 64a, 69a, **77ab**, 78a, 79.
121. *Veremolpa micra* (Pilsbry)	2b, 3b, 5b, 11a, 29a, 33a, 37b, 38ab, 42a, 43b, 49ab, **51ab**, **52ab**, 53ab, 57a, 68b, 76ab.
122. *Anomalodiscus squamosus* (Linné)	8b, 14b, **15ab**, 19ab, 28ab, **33ab**, 35ab.
123. *Protothaca* (*Protothaca*) *jedoensis* (Lischke)	1a, 15a.
124. *Tapes* (*Amygdala*) *japonica* (Deshayes)	6ab, 7b, 9a, 14a, 15ab, 19a, 25a, 26b, 28ab, 33ab, 34a, 35b, 70ab.
125. *Paphia* (*Paphia*) *euglypta* (Philippi)	20a, 62b, 64a, 77b.
126. *Paphia* (*Paphia*) *schnelliana* (Dunker)	68a.
127. *Paphia* (*Paphia*) *exarata* (Philippi)	78b.
128. *Paphia* (*Paratapes*) *undulata* (Born)	2ab, 3ab, 4b, 5ab, 6a, 7ab, 8ab, 9ab, 10ab, 11a, 12a, 13ab, 14b, 15b, 16ab, 19a, 23ab, 25ab, 27b, 28a, 29b, 31ab, 32ab, 34b, 35ab, 36a, **38a**, 39ab, 40b, 41a, 45b, 46ab, 47ab, 50a, 51ab, 52b, 53ab, **65a**, 68b, 71b.
129. *Clementia* (*Clementia*) *vatheleti* Mabille	1b, 2b, 7b, 8b, 16a, 20b, 21b, 25a, 50b.
130. *Irus mitis* (Deshayes)	3b, 14a, 17a, 20a, 39b, 44a, 53a, 57b, **75a**, 77b, 80.
131. *Irus ishibashianus* Kuroda et Habe	11b, 20b.
132. *Petricola divergens* (Gmelin)	5b, 11a, 79.
133. *Caecella chinensis* Deshayes	4a.
134. *Spondervilia bisculpta* (Gould)	1b, 3b, 6ab, 7a 12b, 14a, 19a, 33a, 35b, 43ab, 47a, 58ab, 59a, 60ab, 68a, 77a, 79b.
135. *Mactra sulcataria* Reeve	32b, 47a, 49a.
136. *Mactra veneriformis* Reeve	19a.
137. *Mactra* (*Mactrotoma*) *angulifera* Reeve	20a.
138. *Raeta* (*Raetellops*) *pulchella* (Adams et Reeve)	2b, 3b, 5b, 7a, 8b, 9a, 10b, 11a, 12a, 13b, 14b, 16b, 18a, 20b, 21a, 22b, 27b, 30b, 31a, 32a, 36b, 38b, 45b, 49a, 51a, 77a.
139. *Standella* (*Meropesta*) *nicoborica* (Gmelin)	6ab, 14a, 33ab.
140. *Lutraria arcuata* Reeve	11b, 77b.
141. *Tentidonax kiusiuensis* (Pilsbry)	34a.

142. *Heteroglypta nipponica* Kuroda — 79.

143. *Gari anomala* (Deshayes) — 2a, 77a.

144. *Psammotaea minor* (Deshayes) — 49a.

145. *Rochefortia hawaiiensis* Dall Bartsch et Rehder — 43b.

146. *Solecurtus divaricatus* (Lischke) — 61b, 77b.

147. *Azorinus abbreviatus* (Gould) — 1b, 2b, 4a, 5a, 6ab, 9b, 11b, 13b, 16a, 19ab, 20a, 33a, 40b, 43ab, 44a, 47b, 48b, 53ab, 57ab, 62ab, 63ab, 64b, 66b, 67a, 68a, 70b, 77b, 78a.

148. *Leptomya minuta* Habe (sp. nov.) — 1ab, 2b, 3ab, 4a, 5ab, 7a, 12b, 13ab, 14a, 16a, 20a, 25a, 30b, 40ab, 42ab, 43ab, 44a, 46a, 47ab, 48b, 49b, 51b, 53ab, 57ab, 62ab, 66ab, 68b, 70a, **76ab**, 77ab, **78b**.

149. *Leptomyaria triga* Habe (sp. nov.) — 7b, 43ab, 52b, 58ab, **61ab**, 62b, 63ab, 64a, 67a, 68a, 79.

150. *Leptomya cuspidariaeformis* Habe — 14b, 57b, 62ab.

151. *Iacra japonica* A. Adams — 36b.

152. *Abra* (*Abrina*) *lunella* (Gould) — 77b.

153. *Theora* (*Endopleura*) *lubrica* Gould — 1b, **2ab**, **3ab**, **4ab**, **5ab**, 6ab, **7ab**, **8ab**, 9ab, **10ab**, **11ab**, **12ab**, **13ab**, 14ab, 15b, **16ab**, **17ab**, **18ab**, **19ab**, **20ab**, **21ab**, **22ab**, **23ab**, **24a**, **25ab**, **26ab**, **27ab**, **28ab**, **29ab**, **30ab**, **31ab**, **32ab**, 33ab, **34ab**, **35ab**, **36ab**, **37ab**, **38ab**, **39ab**, **40ab**, **41ab**, 42ab, 43ab, 44a, **45ab**, **46ab**, **47ab**, 48b, 49b, **52ab**, 53ab, 55ab, **56ab**, 57a, 62a, 63ab, 64ab, **65ab**, **66ab**, 67a, 68b, 69ab, 70ab, **71ab**, **76a**b, 77b, **78ab**.

154. *Elliptotellina euglypta* (Gould) — 79.

155. *Punipagia hypelliptica* (Salisbury) — 1ab, 2b, 3ab, 4a, 5b, 6b,7a, 8b, 9a, 11ab, 14ab, 19ab, 20ab, 25a, 33b, 39b, 42a, 43ab, 44a, 53b, 57ab, 58ab, 59ab, 60ab, 61b, 77ab.

156. *Clathrotellina carnicolor* (Hanley) — 4b, 25b, 62b.

157. *Arcopella isseli* (H. Adams) — 42a, 53a, 64ab.

158. *Arcopagia* (*Merisca*) *diaphana* (Deshayes) — 19a.

159. *Macoma* (*Macoma*) *praetexta* (v. Martens) — 47a.

160. *Macoma* (*Macoma*) *tokyoensis* Makiyama — 69a.

161. *Macoma* (*Macoma*) *incongrua* (v. Martens) — 6b, 9b, 14b, 15ab, 19ab, 28a, 33a, 34a.

162. *Macoma* (*Psammacoma*) *awajiensis* Sowerby — 2b, 4a, 5b, 6a, 7b, 8b, 9a, 10a, 11b, 12a, 17b, 19a, 20b, 21a, 22ab, 25b, 28a, **29ab**, 31a, 32ab, 35ab, 37a, 38ab, 40a, 41a, 42a, 43ab, 47ab, 49b, 52b, 53ab, 56b, 57ab, 64b, 65b, 66b, 68b, **69ab**, **71b**, 77a.

163. *Pseudometis praerupta* (Salisbury) — 37b.

164. *Moerella jedoensis* (Lischke) — 3ab, 4a, 30b, 44a, 51b, 52b, 53ab, 58a, 68ab.

165. *Moerella juvenilis* (Hanley) — 14a, 19a.

166. *Semelagulus kurodai* (Makiyama) — 49b, 58ab, 60ab, 61a, 79ab.

167.	*Fabulina minuta* (Lischke)	1ab, 2ab, 3ab, 4ab, 5ab, 6ab 7ab, 8ab, 9ab, 11ab, 12ab, 13ab, 14ab, 16b, 17a, 18b, 19ab, 20ab, 23b, 25a, 30ab, 32b, 33ab, 36ab, 43ab, 44a, 46a, 47ab, 49a, 51b, 53a, 57ab, 58ab, 59b, **61ab**, 62ab, 63ab, 64a, 65a, 66b, 68b, 70a, 76a, 77ab.
168.	*Fabulina nitidula* (Dunker)	2ab, 6ab, 15b, 19a, 20a, 24b, 28a, 30b, 32b, 33ab, **36ab**, 43b, 47a, 48b, **50a**, 51a, 53ab, 58a, 61b, 62ab, 66ab, **67b**, 68b, 69b, 70b, 71b.
169.	*Jactellina* (*Loxoglypta*) *lauta* (Gould)	58b.
170.	*Angulus vestalioides* (Yokoyama)	12a, 20a, 22b, 47a, 56b, 77b.
171.	*Tellinella pulcherrima* (Sowerby)	68a, 77b.
172.	*Pharaonella perieri* (Bertin)	58ab, 60b.
173.	*Siliqua pulchella* (Dunker)	48b.
174.	*Ensiculus philippianus* (Dunker)	3b, 36a, 48b, 49a, 57b, 61b, 68b.
175.	*Solen intermedius* Koch	36b, 50b, 51b.
176.	*Solen roseomaculatus* Pisbry	77b.
177.	*Hiatella orientalis* (Yokoyama)	3b, 5a, 8b, 10b, 11a, 14b, 20ab, 41a, 42a, 44a, 52ab, 53a, 54a, 57ab, 58a, 68b, 77b, 79a.
178.	*Varicorbula bifrons* (A. Adams)	77b.
179.	*Anisocorbula minutissima* Habe	2b, 10a, 11a, 20a, 41a, 42a, 44a, 53a, 56a, 57a, 62ab, 63ab, 64a, **65b**, 68a, 76b, 77ab.
180.	*Mya* (*Arenomya*) *japonica* Jay	14b, 19b.
181.	*Cryptomya busoensis* Yokoyama	3b, 11b, 25ab, 53a.
182.	*Sphenia coreanica* Habe	44a, 53ab, 57a.
183.	*Rocellaria* (*Cucurbitula*) *cymbium* (Spengler)	4a, 7a, 12b, 64a.
184.	*Gastrochaena grandis* (Desheyes)	77b.
185.	*Barnea* (*Anchomasa*) *manilensis inornata* (Pilsbry)	9a, 14a, 19a, 43a, 50b, 57b, 75b, 76b, 77b.
186.	*Zirfaea subconstricta* (Yokoyama)	57a, 58b.
187.	*Teredo japonica* Clessin	76b.
188.	*Pandora* (*Kennerlia*) *pseudobilirata* Nomura et Hatai	42b.
189.	*Myadora reeveana* Smith	79b.
190.	*Myadora fluctuosa* Gould	41a.
191.	*Cyathodonta granulosa* (Adams et Reeve)	32b.
192.	*Trigonothracia* pusilla Gould	3b, 5a, 20a, 66ab, 67a, 76a.
193.	*Thraciopsis transmontana* (Yokoyama)	79.
194.	*Laternula Laternulina flexuosa* (Reeve)	2a, 3ab, 5b, 6a, 7b, 8b, 9a, 10a, 12b, 13a, 14ab, 17a, 18a, 19b, 25ab, 35b, 42a, 51b, 53a, 64a, 70a.
195.	*Plectodon* (*Pseudoneaera*) *tanabensis* Habe (sp. nov.)	57b.

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DISTRIBUTION OF SULFATE-REDUCING BACTERIA IN MAIZURU BAY

By
Masao Kimata, Hajime Kadota, Yoshihiko Hata and Hideo Miyoshi
(Kyoto University)

In the previous papers[1)2)] concerning the ecology of sulfate-reducing bacteria in Hiroshima Bay we reported that hydrogen sulfide and metallic sulfides found in abnormally high concentrations in the sea water and in the bottom mud near the draining mouths of pulp and paper factories resulted from the reduction of sulfate by the activity of sulfate-reducing bacteria accelerated by the organic matter which was supplied by drainages from the factories.

The present paper summarizes the results of the observations carried out a whole year in Maizuru Bay to detect local and seasonal fluctuations in the distributions of sulfate-reducing bacteria, sulfides, organic matter, etc. Maizuru Bay is a narrow bay located on Japan Sea Coast of Japan and receives organic drainages from paper and food factories as well as municipal drainages from Maizuru City.

1. It was found that the concentrations of organic matter, hydrogen sulfide, metallic sulfides, and sulfate-reducing bacteria in the water as well as in the bottom mud in Maizuru Bay were generally higher than those in Hiroshima Bay, with a few exceptions.

2. The local fluctuation in the abundance of sulfate-reducing bacteria in Maizuru Bay was not distinct as compared with the case in Hiroshima Bay. In the former bay there were no remarkable differences in numbers of sulfate-reducing bacteria in the bottom water as well as in the bottom mud between the stations near the entrance to the bay where the water and the bottom mud were not directly polluted with the drainages and the stations near the mouths of drainages or the oyster farms where organic matter was accumulated in high concentration. On the other hand, the concentrations of hydrogen sulfide and metallic sulfides in the mud, and the content and saturation percentage of oxygen in the bottom water showed relatively distinct differences with the locality of the station; it was observed at the stations near the draining mouths or the oyster farms that the concentration and saturation percentage of oxygen

1) M. Kimata, H. Kadota, Y. Hata and T. Tajima, B. J. S. S. F., *21*, 102–108 (1955)
2) M. Kimata, H. Kadota, Y. Hata and T. Tajima, Rec. Oceanogr. Works Japan, *2*, 85–93 (1955)

in the water were somewhat lower, and the contents of sulfides in the mud were relatively higher than those at the stations near the entrance of the bay.

The differences with the locality in the oxygen concentration and in the sulfide content were most marked in late summer when the temperature of the bottom mud was highest throughout the whole year.

3. These results suggest that the organic content of the bottom mud was large enough for the abundant growth of sulfate-reducing bacteria in the mud everywhere in Maizuru Bay, and that the concentration of available organic matter in the mud at the stations near the entrance of Maizuru Bay was not sufficient for the maximum production of sulfides by sulfate-reducing bacteria. These are probably due to the fact that sulfate-reducing bacteria require organic matter in higher concentration for the maximum production of sulfides than for the maximum growth.

The difference between the results obtained with Maizuru Bay and those obtained with Hiroshima Bay may be attributable to the fact that the movements of water in the former are far less than those in the latter; in the former bay organic matter supplied from the industrial and municipal drainages is easily accumulated in the bottom mud, whereas in the latter bay organic substances from the drainages tend to be dispersed by the intense movement of the water.

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ON THE SHORT PERIOD VARIATIONS OF OCEANOGRAPHICAL CONDITIONS IN THE KUROSHIO REGION

(Preliminary Report)

By

Yositada Takenouti* and Masasi Yasui**

(*Meteorological Research Institute. **Japan Meteorological Agency)

1. Long term variations for the path, transport, etc. of the Kuroshio have been studied by many authors, but few studies have been made for the short period variations. The mixing may be in close relation to the short period variations, and formation and degeneration of the Kuroshio water mass are brought about by them, so it is very interesting problem in the oceanography to study the short period variations. For a practical application, it may closely related to fisheries, because when a thermocline is going up and down by an internal wave, fish shoals may change their migrating depth according to the change of depth of their optimum water temperature.

One of the authors made some observations for the short period variations of the Kuroshio in the sea area off south of Kyushu on board the training ship, Keiten Maru of the Kagoshima University, in cooperation with Dr. C. S. Cox and Dr. K. Yoshida. The observations were made at St. 1 (30°N, 136.5°E) for 24 hours, St. 2 (28°N, 134°E) for 48 hours and St. 3 (28°N, 131°E) for 24 hours. The stations are illustrated in Fig. 1 together with the bottom topography near the stations. It is noticeable from the figure that St. 1 is lying near a sea mount, St. 2 on a flat bottom and St. 3 at the margin of basin.

The observations consisted of BT measurements for every 30 minutes and hydrographic cast of 250, 300, 350 and 400 meters with Nansen bottles and reversing thermometers at every 2 hours. The emphasis was put on finding a change of the depth of thermocline. The thermocline was, however, not so clear and not well defined as, at the period of observations, the summer thermocline between a surface mixing layer and an intermediate layer was going to form, and it was not so conspicuous yet. Therefore an internal wave was rather clearly notified by means of the depth of isotherms than that of thermocline.

2. Variations of the depth of isotherms at each station are illustrated in Fig. 2. Short period variations are predominant, but these are not stable. Beside them, diurnal and semidiurnal variations are readily seen in the figure. From the

cotidal chart near Japan, we can find that the K_1 and M_2 tide at the stations are in the same phase with those at Aburatsu. Comparing the figures with the predicted tide curve at Aburatsu, it is found that at the time of high and low water, the depth of isotherm is deep and shallow respectively.

Amplitudes of the isotherms are about 20 meters around the depth of 150 meters and 50 meters around 350 meters, and the phase coinsides fairly well with them. Judging from this fact, the internal wave at the stations is coming from the deeper layer below the observed layers rather than produced at the thermocline. But to verify it is impossible because the measurements are limited to the depth of 400 meters.

At the latitude 28°N, a pendulum day is 51 hours, and the half pendulum day is very close to the period of dinural tide, 25 hours. Therefore, it is impossible to conclude whether the internal wave has an inertia period or a tidal period. It is also very difficult to discuss the effect of bottom configuration upon the internal wave because of the scantiness of data, although the stations are located at the different bottom configurations.

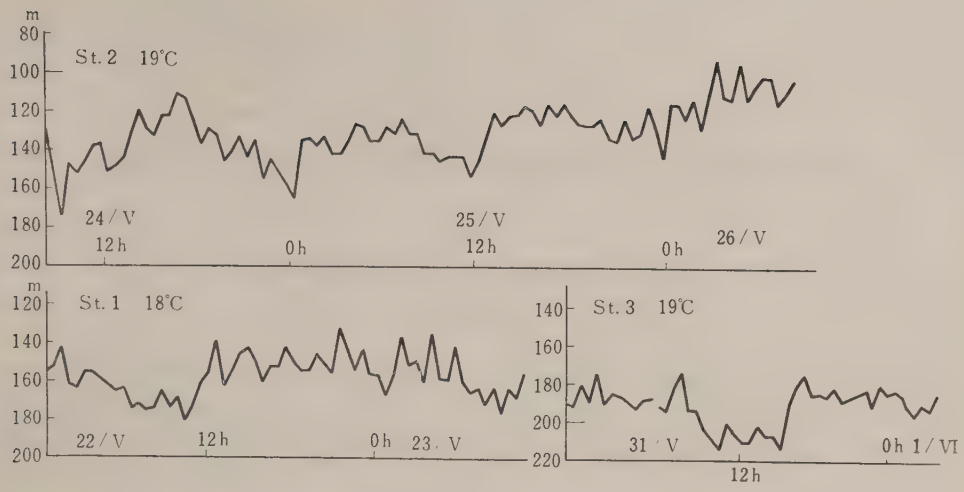

Fig. 1. The stations and the bathymetric curves

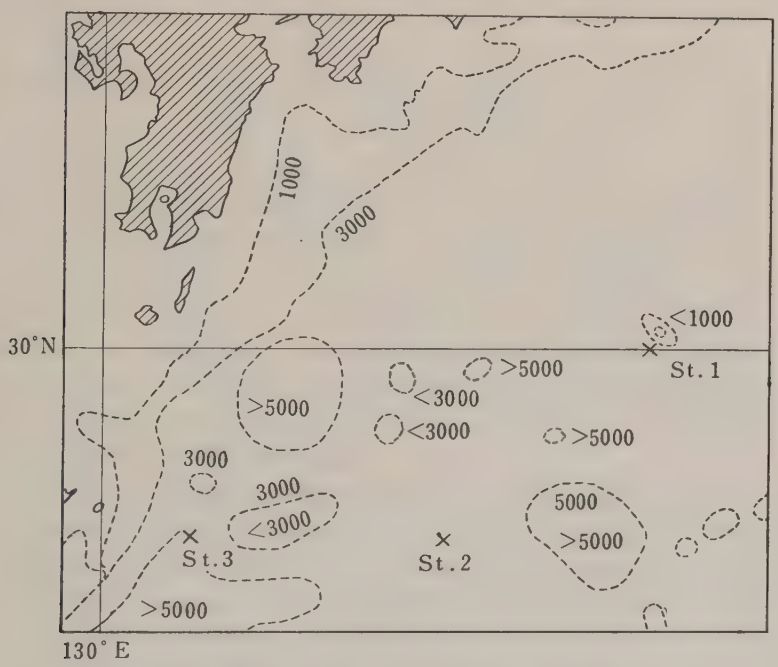

Fig. 2. Variations of isotherms at the stations

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RESEARCHES ON THE CURRENTS OF KUROSHIO

By
Michitaka Uda and Makoto Ishino
(The Tokyo University of Fisheries)

The following paper is the report of the oceanographic surveys made by the Umitaka-maru (1453 tons), the training ship of the Tokyo University of Fisheries, over the frontal zone of Kuroshio during 22–24 June of 1958 and 22–25 March of 1959.

In this place the authors wish to state their hearty thanks to Mr. Yūzō Komaki of the Tokyo University who helped us during the former survey and to Mr. Keiji Nasu of the Whales Research Institute who helped us during the latter survey.

Hydrography in the Polar Frontal Zone east to Japan during Late June of 1958

1. Stations observed as shown in Fig. 1 were chosen in the area around Kinkazan. Arrows at the stations in Fig. 1 indicate the direction of surface current measured by G.E.K. with the attached figures representing the current speed in knot. (Refer observed data in the Table 1 of appendix.)

On the coastal side north to Kinkazan in this area the northerly current prevailed with the velocity of about 0.2 knot and in particular 0.5 knot at the northernmost St. 5. Generally at the stations in the offing southern sea-region southgoing current of 0.4∼0.6 knot was observed and not in coincidence with the running direction of isothermal lines.

At that time the Kuroshio Main Current flows in the easterly direction off Cape Inubōzaki (referred to the report of the Tōhoku Regional Fisheries Research Laboratory) and not so strong is the inflow into the above-mentioned area. Accordingly, owing to the alternating period of the intensity of cold and warm currents, and as well as to the meandering nature of the Kuroshio Front, it seems that such a complex pattern of currents might be formed. However, to our regret too scanty observing stations were covered to follow the streamlines in this region comprehensively.

2. Horizontal distributions of water temperature and salinity at sea surface were mapped in Figs. 2 and 3. A cooler water (water temperature below 16°C) assigned to coastal water mass was formed nearly in the area off Kinkazan, while in the offing region extending from 40°N, 143°E to 37°N, 141.5°E a water

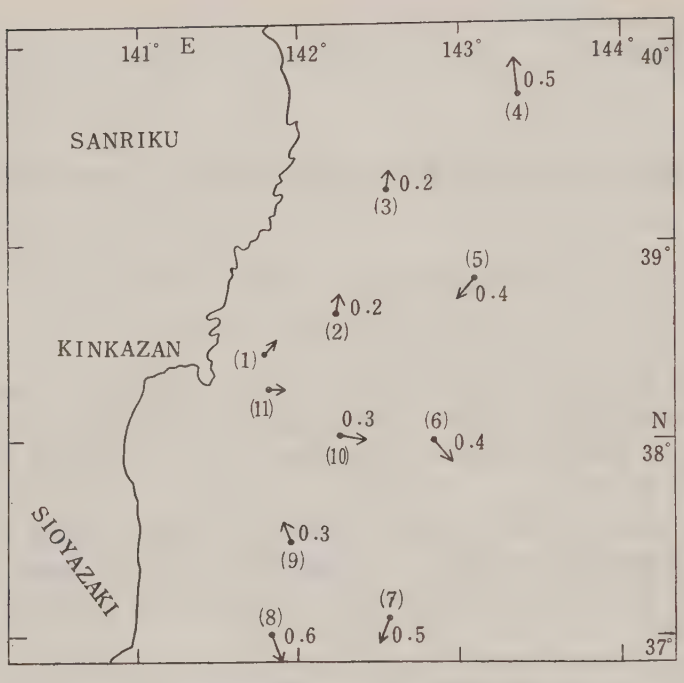

Fig. 1. Observing station map off Sanriku (22–24 June, 1958, Umitaka-maru), surface currents (speed in knot, and direction) by G. E. K.

mass of temperature higher than 18°C was remarked, which may indicate the trend of gradual warming from southeast offing in the northeastern sea-region of Japan.

In general, thermocline lies in the layer of 25~50 m in depth. We find nearly thermal homogenuity in the deeper layer below it (less than 5°C deeper than the 200~400 m). The distribution of the salinity corresponds to that of water temperature. In the cooler zone in the area east to Kinkazan was broadly distributed low saline water having the salinity less than 33.8 ‰ (Sts. 5, 9 etc.). Particularly water of low salinity at St. 5 locates at the area of the cold Oyashio Intrusion, as shown by the current measurment by G.E.K.. At southerly located St. 7 the saline water (S higher than 34.4 ‰) well coincides with the warm water distribution.

3. Fig. 4 indicates the vertical distribution of water temperature and salinity at the stations 6, 8, 9 and 10 where the dichothermal water was found. Two meridional sections of water temperature and salinity in the offing and near coast (Fig. 5a and Fig. 5b) show the existence of dichothermal water lying at the depth of 200~400 m with pretty well coincidence of temperature minimum with the salinity minimum along the sections (dichothermal layer deeper than the intermediate salinity minimum layer). This means the effect of the

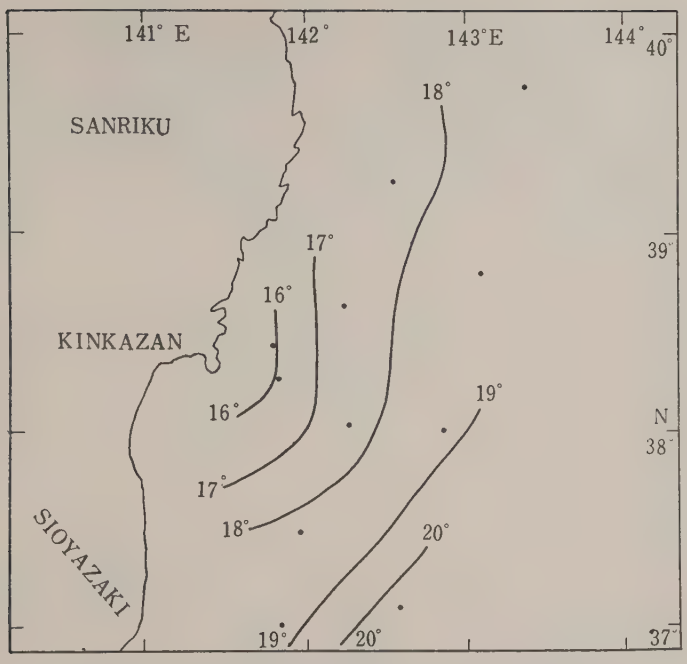

Fig. 2. Distribution of surface water temperature (°C) off Sanriku during late June of 1958

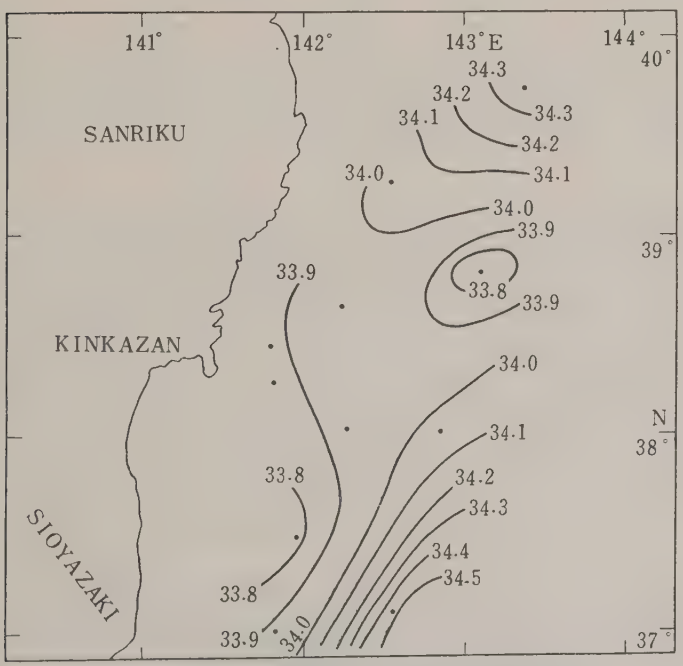

Fig. 3. Salinity (‰) at the sea surface off Sanriku during late June of 1958

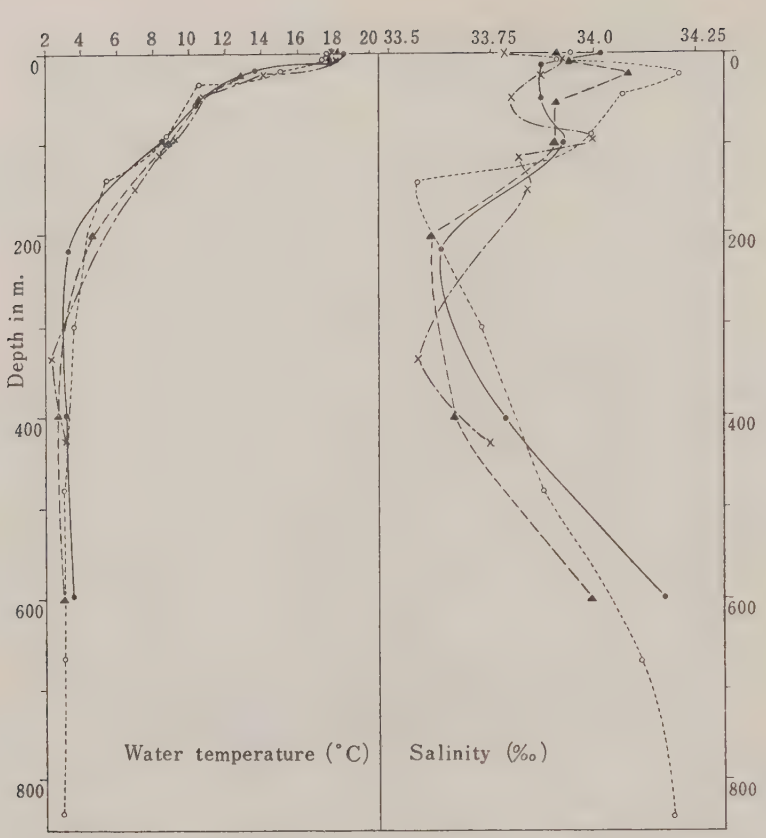

Fig. 4. Vertical distribution of water temperature and salinity at St. 6 (●) St. 8 (▲), St. 9 (×), St. 10 (○) of Fig. 1.

warm water intrusion in the surface layer in addition to the stronger advectional effect of Oyashio Undercurrent along our meridional sections of Polar Frontal Zone. In those above dichothermal and intermediate salinity minimum layers we can recognize the water temperature 2~4°C and salinity 33.5~33.7 ‰.

The quantity of dissolved oxygen in the upper euphotic layer above the 200 m depth is more than 5 cc/L, representing its first O_2 maximum at about 25~50 m depth due to the photosynthesis of phytoplankton and also its second O_2 maximum at about 150~200 m depth due to the advectional effect by Oyashio Undercurrent along the upper zone of intermediate (salinity minimum) water. The dissolved oxygen declines remarkably in the 350~450 m depth showing (oxycline) 2~3 cc/L.

It is interesting to find an isolated saline water (S 34.2‰) in the upper layer at stations 2, 3 and 10 along the coastal section, which may be presumably originated from the branched Kuroshio system water by the cut-off or blocking action.

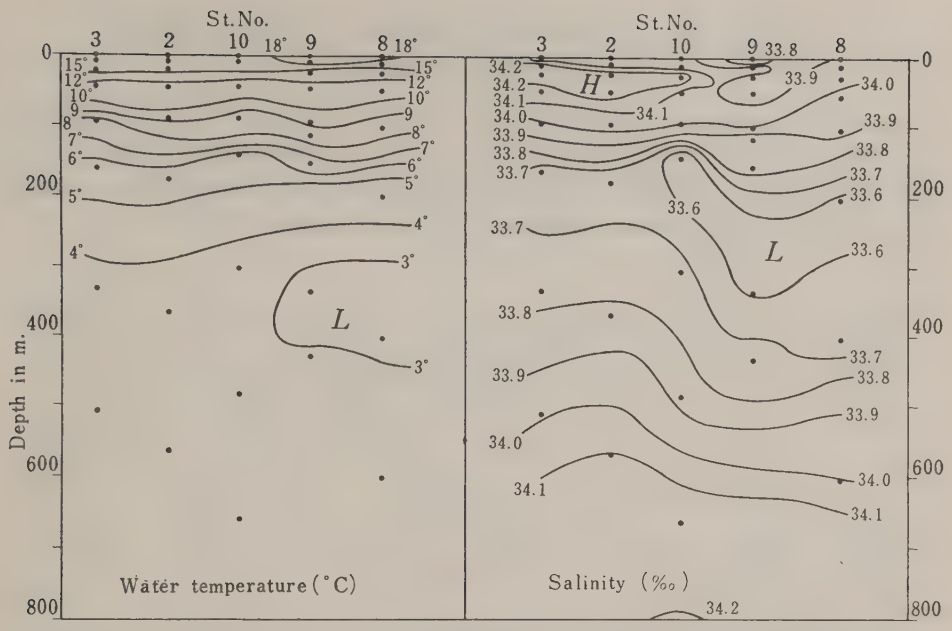

Fig. 5a. Meridional section along coastal side concerning the distributions of water temperature and salinity

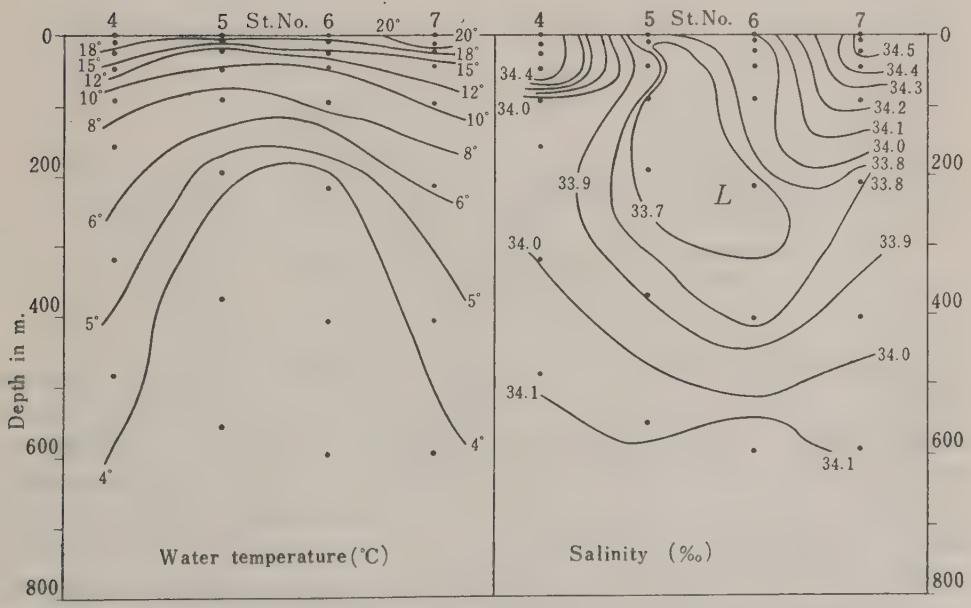

Fig. 5b. Meridional section of water temperature and salinity along offing side

Hydrography in the Sea-region south off Sikoku during late March of 1959

1 Stormy weather hindered us from the first planned survey around the cold water mass off Sionomisaki. We carried out the oceanographic survey over the sea-region south off Sikoku as shown in Fig. 6. The illustrated current speed and direction were obtained by G.E.K. as indicated before.

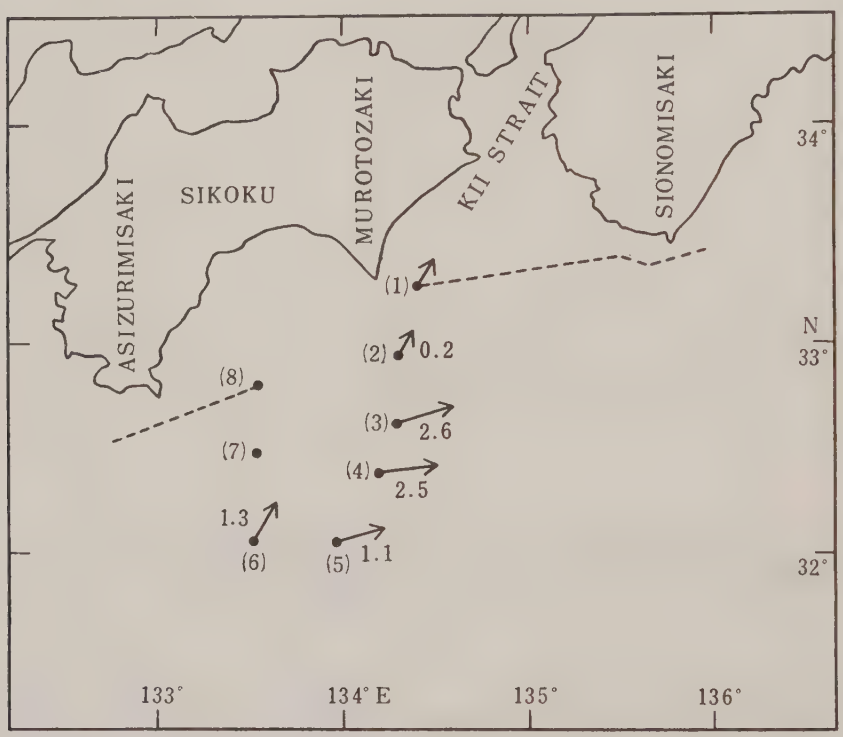

Fig. 6. Observing station map off Sikoku and surface currents (speed in knot, and direction) by G. E. K.

The horizontal distributions of water temperature and salinity at the sea surface are shown in Figs. 7 and 8. Basing on those maps we can infer the Main Kuroshio Current flowing nearly in eastnortheasterly direction with pretty fast speed of about 2.5 knots further 40 seamiles south off Cape Murotozaki towards the sea off Sionomisaki. We crossed a conspicuous surface of water temperature discontinuity at about 32°–43′N, 134°–15′E and at about 32°–42′N, 133°–35′E just in correspondence to the above mentioned Kuroshio Main Current. Accordingly the abrupt temperature rise from 19°C to 21°C towards south was registered on the thermograph.

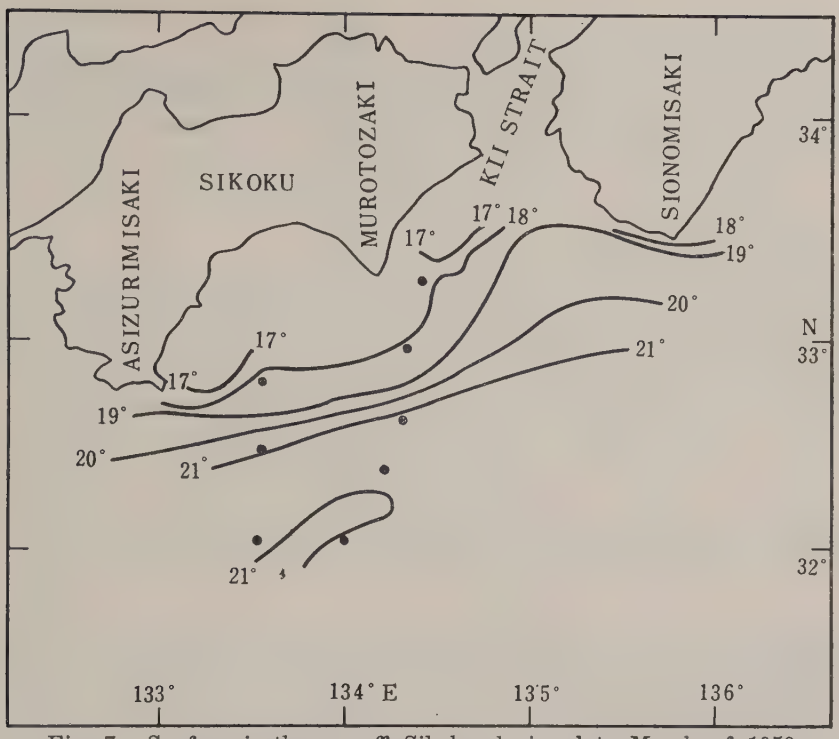

Fig. 7. Surface isotherms off Sikoku during late March of 1959

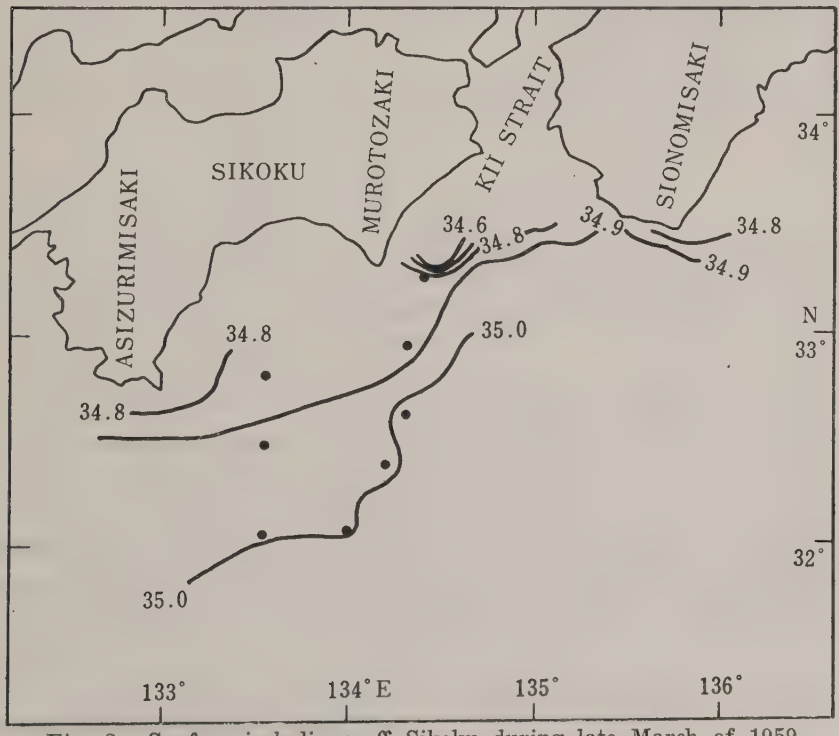

Fig. 8. Surface isohalines off Sikoku during late March of 1959

Stronger inflow of eastnortheasterly Kuroshio Current produced the warm (above 19°C) and saline (above 34.9 ‰) water in the eastern part of Kii Strait, contrary to the extension of the cooler water (below 17°C) having low salinity (less than 34.7 ‰) in the western part of Kii Strait, probably due to the prevailing outflow of the inland (coastal) water. Similarly in the sea-region east to Asizuri Misaki the water of temperature below 17°C and of salinity less than 34.7 ‰ prevailed.

At the southern stations 3, 4, 5 and 6 located in the Kuroshio Main Current the distribution of the water temperature higher than 21°C and salinity higher than 35.0 ‰ was observed. These evidences suggest the sign of prevailence of Kuroshio System Water. (At Sts. 7 and 8 the current measurements by G.E.K. were missed due to the unexpected instrumental troubles.)

2 The sectional profile of water temperature and salinity along the line south off Cape Murotozaki is shown in Fig. 9. The existence of the frontal surface of the Kuroshio on the coastal side between Sts. 2 and 3 is clearly recognized also by this map, showing the abrupt change of water temperature and salinity.

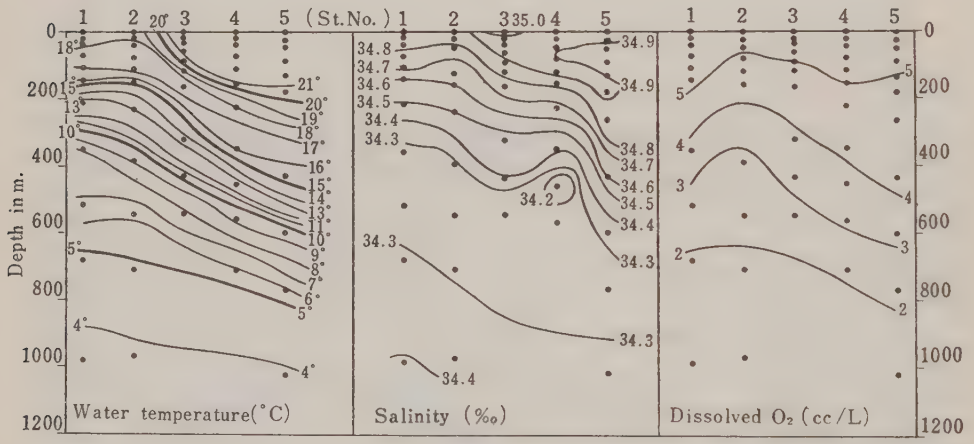

Fig. 9. Meridional sections south off Murotozaki concerning water temperature, salinity and dissolved oxygen during late March of 1959

In general, the warm and saline layer is thicker from north to south (towards the right-hand side of the flowing direction of Kuroshio Stream), attaining to about 200 m depth at St. 5 and higher than 20°C and above 34.9‰. The fact that around Sts. 3 and 4 the isothermal lines, isohalines and isopycnals run down most steeply in the profile, and indicate the existence of strongest current-belt of the Kuroshio Main at that portion. The dissolved oxygen is rich above 5 cc/L in the upper layer to 100 m depth and decays to about 2 cc/L in deeper layer at 600～700 m depth not showing much difference by localities.

The socalled Intermediate Water lies at about 400～700 m depth, showing

water temperature at about 10°C, salinity 34.2~34.5 ‰ and dissolved oxygen about 2~3 cc/L.

3 Summarizing above, the flow pattern of Kuroshio seems to be almost normal. No indication of anomalous meander of Kuroshio during this period is seen.

Concluding Remarks

During this period the cruise schedule has not allowed us to undertake surveys in the same sea-region repeatedly in different season. Also the stormy weather during our survey has not favoured us. Since the influence of Kuroshio Current and its fluctuation on the marine fisheries of skipjack, tunas, yellow-tail, sardine etc. are so profound, our researches and surveys concerning those problems should be continued further in future.

The abstract of our results are as follows:

A. Sea-region east off Sanriku in late June of 1958.

a. The season corresponds to the alternating (transitional) period of cold and warm currents. We found an earlier isolated (cut-off) warm Kuroshio Water mass.

b. The direction of currents in the Polar Frontal Zone in this period is especially complicated.

c. Near the coast of Kinkazan the cooler coastal water existed. However, in the southeast offing of Kinkazan already the remarkably developed Kuroshio Water intruded to north.

d. Dichothermal water was found broadly at Sts. 6. 8. 9 and 10 off Kinkazan (38°N) and Cape Sioyazaki (37°N), and that suggested us the southerly prevailence of the Oyashio Cold Water (subarctic water mass).

e. Such development of oceanic front has contributed to the formation of favourable skipjack fishing ground in this summer.

B. Sea-region off Sikoku during late March of 1959.

a. The Kuroshio Main Current has flown in the eastnortheasterly direction about 40 seamiles south off Cape Murotozaki with the pretty strong speed of 2.5 knots.

b. The northern edge of Kuroshio located at about 32°–43′N, 134°–15′E 32°–42′N, 133°–35′E.

c. The indices of the Kuroshio frontal surface may be taken as water temperature 20°C and salinity 34.9 ‰.

d. Due to the ENE inflow of Kuroshio Current the remarkable warming of eastern part of Kii Strait was resulted, in contrast to the outflow of the extended coastal water in the western side of Kii Strait. Such sea condition may be correlated to the poor catch of yellow-tail in the waters southwest to this strait.

e. In this period the Kuroshio pattern seems to be almost normal, with no indication of meander in this area.

Table 1. Oceanographical data

Off Sanriku

St. 1. 38°–28.′8N, 141°–53.′5E, 22, June, 1958, Sonic depth 232, Wind S/E 3, Weather b, Air Temp. 18.8, Transparency 20, Color of Sea 3, Current NE —.

Depth	Temp.	Cl	S	O_2	pH
0	15.9	18.76	33.89	6.14	8.3
9	15.11	18.725	33.83	5.99	8.3
23	14.46	18.72	33.82	6.39	8.3
45	13.44	18.74	33.86	6.48	8.2
90	11.28	18.82	34.00	6.15	8.2
146	10.30	18.82	34.00	5.92	8.2

St. 2. 38°–42.′5N, 142°–22.′0E, 22, June, 1958, Sonic depth 850, Wind S 4, Weather b, Air Temp. 18.8, Transparency 21, Color of Sea 3, Current 5°–0.′22.

Depth	Temp.	Cl	S	O_2	pH
0	17.4	18.79	33.95	5.82	8.25
9	17.46	18.82	34.00	5.87	8.2
23	15.88	19.00	34.33	6.11	8.2
46	11.99	18.94	34.22	4.69	8.15
93	8.96	18.85	34.05	5.01	8.15
177	5.64	18.64	33.68	5.47	8.0
367	3.63	18.72	33.82	3.06	7.8
564	3.43	18.875	34.10	1.37	7.7

St. 3. 39°–15.′5N, 142°–34.′5E, 22, June, 1958, Sonic depth 1262, Wind SSW 4, Weather b, Air Temp. 18.4, Transparency —, Color of Sea —, Current 5° 0.2′.

Depth	Temp.	Cl	S	O_2	pH
0	17.85	18.83	34.02	5.73	8.3
9	17.88	18.97	34.27	5.67	8.3
23	15.17	18.99	34.31	6.05	8.3
46	11.60	18.88	34.11	5.57	8.2
93	7.94	18.81	33.98	5.19	8.2
161	5.47	18.65	33.69	5.81	8.0
333	3.41	18.67	33.73	3.62	7.9
508	3.11	18.81	33.98	1.58	7.8

St. 4. 49°–43.′2N, 143°–23.′0E, 23, June, 1958, Sonic depth 2350, Wind SSW 4, Weather b, Air Temp. 19.2, Transparency 14, Color of Sea 4, Current 5° 0.45′.

Depth	Temp.	Cl	S	O_2	pH
0	18.2	19.02	34.36	5.65	8.3
10	18.22	19.015	34.35	5.54	8.3
24	17.79	19.09	34.49	5.64	8.3
47	13.51	19.09	34.49	4.07	8.2
94	8.79	18.78	33.93	5.91	8.1
159	6.85	18.81	33.98	4.61	8.0
320	5.04	18.82	34.00	3.44	7.9
483	4.22	18.87	34.09	2.04	7.8

St. 5. 38°–50.′0N, 143°–05.′5E, 23, June, 1958, Sonic depth 1780, Wind S/W 4, Weather b, Air Temp. 19.4, Transparency 20, Color of Sea 4, Current 135° 0.4′.

Depth	Temp.	Cl	S	O_2	pH
0	18.7	18.68	33.75	5.64	8.3
9	17.81	18.68	33.75	5.85	8.3

23	11.58	18.63	33.66	7.22	8.3
46	9.38	18.745	33.86	6.26	8.2
91	6.37	18.61	33.62	6.20	8.1
196	4.40	18.65	33.69	4.95	7.9
376	3.59	18.77	33.91	2.56	7.7
557	3.37	18.86	34.07	1.31	7.65

St. 6. 38°–00.′0N, 142°–48.′6E, 23, June, 1958, Sonic depth 1600, Wind SSE 4, Weather b, Air Temp. 2/.3, Transparency 19, Color of Sea 4, Current 133° 0.4′.

Depth	Temp.	Cl	S	O_2	pH
0	18.8	18.83	34.02	5.03	8.3
10	17.84	18.75	33.87	5.98	8.3
24	13.61	18.75	33.87	6.63	8.3
48	10.26	18.75	33.87	6.36	8.2
96	8.44	18.78	33.93	5.34	8.15
218	3.35	18.61	33.62	5.14	7.9
408	3.25	18.70	33.78	2.41	7.7
598	3.67	18.92	34.18	1.37	7.7

St. 7. 37°–11.′N, 142°–32.′0E, 23, June, 1958, Sonic depth 2060, Wind S/E 4, Weather o, Air Temp. 20.5, Current 204° 0.47′.

Depth	Temp.	Cl	S	O_2	pH
0	20.8	19.12	34.54	5.27	8.3
10	20.71	19.12	34.54	5.30	8.3
25	18.75	19.12	34.54	5.67	8.3
49	14.28	19.05	34.42	4.58	8.2
98	10.43	18.94	34.22	4.63	8.1
216	6.15	18.71	33.80	4.99	8.1
408	4.30	18.80	33.96	2.92	7.9
598	3.58	18.86	34.07	1.50	7.7

St. 8. 36°–59.′5N, 141°–48.′0E, 23–24, June, 1958, Sonic depth 770, Wind S 2, Weather b, Air Temp. 19.5, Current 178° 0.62′.

Depth	Temp.	Cl	S	O_2	pH
0	18.6	18.77	33.91	5.87	8.3
10	17.68	18.79	33.95	6.04	8.3
25	12.83	18.87	34.09	5.33	8.3
50	10.53	18.77	33.91	5.96	8.2
100	8.77	18.77	33.91	5.07	8.1
200	4.68	18.60	33.60	5.84	7.8
400	2.95	18.63	33.66	2.75	7.8
600	3.20	18.82	34.00	1.64	7.7

St. 9. 37°–34.′3N, 141°–58.′8E, 24, June, 1958, Sonic depth 518, Wind S/E 2, Weather C, Air Temp. 20.5, Transparency 18, Color of Sea 4, Current 336° 0.3′.

Depth	Temp.	Cl	S	O_2	pH
0	18.2	18.70	33.78	5.70	8.3
9	18.06	13.78	33.93	5.77	8.3
24	13.98	18.75	33.87	6.57	8.3
47	10.65	18.71	33.80	6.44	8.2
95	9.21	18.82	34.00	5.91	8.15
112	8.37	18.72	33.82	6.01	8.15

153	6.96	18.73	33.84	6.05	8.1
335	2.48	18.58	33.57	4.57	7.8
428	3.24	18.68	33.75	2.85	7.7

St. 10. 38°–09.′5N, 142°–23.2E, 24, June, 1958, Sonic depth 1100, Wind SSW 4, Weather c, Air Temp. 18.7, Transparency 19, Color of Sea 4, Current 103° 0.32′.

Depth	Temp.	Cl	S	O_2	pH
0	17.6	18.79	33.95	5.79	8.3
9	17.43	18.77	33.91	5.90	8.3
23	15.04	18.94	34.22	6.21	8.3
45	10.51	18.86	34.07	5.60	8.2
90	8.70	18.82	34.00	5.13	8.1
139	5.45	18.58	33.57	6.11	8.0
303	3.65	18.67	33.73	3.60	7.8
482	3.12	18.755	33.88	1.88	7.7
661	3.35	18.89	34.13	1.18	7.65
839	2.99	18.93	34.20	0.96	7.65

St. 11. 38°–20.′0N, 141°–54.′0E, 24, June, 1958, Sonic depth 240, Wind SW 4, Weather f, Air Temp. 18.5, Transparency 19, Color of Sea 5, Current 90° —.

Depth	Temp.	Cl	S	O_2	pH
0	15.95	18.74	33.86	6.29	8.3
10	14.00	18.77	33.91	6.48	8.25
24	12.58	18.73	33.84	6.58	8.2
48	11.66	18.82	34.00	6.22	8.15
95	10.52	18.83	34.02	5.75	8.15
141	8.97	18.82	34.00	6.40	8.15
188	7.56	18.73	33.84	—	8.1

South Off Sikoku

St. 1. 33°–15.′0N, 134°–25.′5E, 23, March, 1959, Sonic depth 1330, Wind W 4, Weather c, Air Temp. 14.5, Transparency 13, Color of Sea 4, Current 45° —.

Depth	Temp.	Cl	S	O_2	pH
0	18.2	19.295	34.86	5.03	8.35
18	18.24	19.28	34.83	5.36	8.35
36	18.15	19.29	34.85	5.36	8.3
71	17.12	19.235	34.75	5.36	8.3
106	16.99	19.22	34.72	5.37	8.3
141	16.55	19.145	34.59	5.35	8.3
211	12.62	19.095	34.50	—	—
357	7.81	18.975	34.28	3.93	7.9
515	7.06	18.97	34.27	2.58	7.85
679	4.93	18.99	34.31	1.94	7.85
982	3.36	19.045	34.41	1.81	7.8

St. 2. 32°–56.′3N, 134°–18.′5E, 23, March, 1959, Sonic depth 1290, Wind W/N 4, Weather bc, Air Temp. 14.9, Transparency 20, Color of Sea 3, Current 28° 0.15′.

Depth	Temp.	Cl	S	O_2	pH
0	18.1	19.29	34.85	5.55	8.35
21	—	19.27	34.81	5.44	8.3
41	17.99	19.245	34.77	5.32	8.3
80	17.35	19.20	34.69	4.72	8.3

119	16.95	19.18	34.65	4.40	8.25
158	14.51	19.145	34.59	4.12	8.2
235	12.56	19.095	34.50	—	—
390	8.47	18.97	34.27	2.86	7.9
545	6.03	18.965	34.26	2.24	7.8
706	4.75	18.975	34.28	1.85	7.8
968	3.78	19.015	34.35	1.61	7.8

St. 3. 32°–36.′4N, 134°–18.′0E, 23, March, 1959, Sonic depth 2620, Wind NW/N 4, Weather b, Air Temp. 15.5, Transparency 30, Color of Sea 2, Current 73° 2.6′.

Depth	Temp.	Cl	S	O_2	pH
0	21.5	19.44	35.12	5.18	8.35
15	21.45	19.33	34.92	5.11	8.35
31	21.44	19.325	34.91	5.08	8.35
60	21.31	19.33	34.92	5.06	8.3
88	21.31	19.275	34.82	5.05	8.3
114	19.96	19.275	34.82	4.76	8.3
161	18.13	19.245	34.77	5.21	8.3
220	—	—	—	—	—
320	13.82	19.06	34.43	3.84	8.05
429	11.35	19.045	34.41	3.46	7.9
542	7.80	18.96	34.25	2.66	—

St. 4. 32°–20.′5N, 134°–08.′0E, 23, March, 1959, Sonic depth 2250, Wind NW/W 3, Weather b, Air Temp. 16.2, Transparency 22, Color of Sea 2–3, Current 82° 2.5′.

Depth	Temp.	Cl	S	O_2	pH
0	21.5	19.34	34.94	5.12	8.35
19	21.50	19.34	34.94	5.15	8.35
38	21.38	19.32	34.90	5.05	8.35
75	21.10	19.32	34.90	5.03	8.35
113	21.11	19.34	34.94	5.03	8.35
150	21.10	19.27	34.81	5.03	8.35
223	18.55	19.17	34.63	4.46	8.25
348	16.02	19.045	34.41	4.37	8.15
455	12.00	18.93	34.20	3.68	8.05
561	9.37	18.975	34.28	3.11	7.95
708	6.16	—	—	2.30	7.8

St. 5. 32°–02.′5N, 133°–58.′5E, 23, March, 1959, Sonic depth 3920, Wind NW 3, Weather b, Air Temp. 18.3, Current 58° 1.03′.

Depth	Temp.	Cl	S	O_2	pH
0	21.4	19.36	34.98	5.18	8.35
22	21.46	19.32	34.90	5.08	8.35
43	21.48	19.32	34.90	5.07	8.35
87	21.43	19.275	34.82	5.07	8.35
130	21.18	19.295	34.86	4.99	8.35
173	20.38	19.33	34.92	4.64	8.35
259	—	19.315	34.89	4.46	8.3
429	15.30	19.17	34.63	4.36	8.2
598	9.97	19.035	34.39	3.22	7.95
767	5.75	18.955	34.24	2.25	7.8
1018	3.81	19.02	34.36	1.60	7.75

St. 6. 32°–01.′5N, 133°–32.′0E, 24, March, 1959, Sonic depth 2300, Wind S 2, Weather o, Air Temp. 17.3, Transparency 31, Color of Sea 2, Current 26° 1.25′.

Depth	Temp.	Cl	S	O_2	pH
0	21.8	19.28	34.83	5.02	8.35
24	21.81	19.36	34.98	5.12	8.35
48	21.83	19.365	34.98	5.05	8.35
95	21.11	19.365	34.98	5.11	8.35
142	21.07	19.35	34.96	5.16	8.35
189	19.77	19.335	34.93	5.24	8.35
284	17.93	19.27	34.81	4.59	8.3
474	13.56	19.095	34.49	4.03	8.2
668	7.47	18.97	34.27	2.65	7.85
864	4.79	19.005	34.33	1.69	7.75
1163	3.30	19.075	34.46	1.77	7.75

St. 7. 32°–27.′5N, 133°–34.′0E, 24, March, 1959, Sonic depth 920, Wind ENE 7, Weather r, Air Tepm. 13.9, Transparency 14, Color of Sea 4, Current — —.

Depth	Temp.	Cl	S	O_2	pH
0	21.5	19.33	34.92	5.06	8.35
25	21.63	19.33	34.92	5.17	8.35
49	21.57	19.33	34.92	5.08	8.35
94	21.09	19.33	34.92	5.10	8.35
140	19.54	19.275	34.82	5.12	8.35
186	19.14	19.335	34.93	5.03	8.35
275	15.82	19.18	34.65	4.27	8.2
360	12.34	19.09	34.49	3.63	8.05
516	9.99	18.95	34.24	2.73	7.85
657	5.34	18.995	34.32	2.04	7.8

St. 8. 32°–48.′0N, 133°–33.′0E, 24, March, 1959, Sonic depth 870, Wind N/E 4, Weather r, Air Temp. 10.4, Transparency 20, Color of Sea 3, Current — —.

Depth	Temp.	Cl	S	O_2	pH
0	18.8	19.285	34.84	5.35	8.35
17	18.91	19.285	34.84	5.30	8.35
33	18.94	19.285	34.84	5.26	8.35
67	18.29	19.22	34.72	5.12	8.35
100	17.44	19.23	37.74	5.20	8.35
134	16.53	19.20	34.67	4.62	8.25
199	14.19	19.135	34.57	4.07	8.2
268	11.19	19.025	34.37	3.70	8.0
351	9.43	18.99	34.31	3.61	8.0
416	7.51	18.975	34.28	2.97	7.95

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CHEMICAL STUDIES ON THE OCEAN (Part 78)

CHEMICAL STUDIES ON THE SEAWEEDS (VI)

The Content of Calcium, Magnesium and Phosphorus in Seaweeds

By

Masayoshi Ishibashi* and Toshio Yamamoto

(*Department of Chemistry, Faculty of Science, Kyoto University)

It is well known that calcium, magnesium and phosphorus are the fundamental elements which exist universally in the biological materials and their physiological meanings are significant and multiple. These elements in plants have been studied from the viewpoints of agricultural chemistry, plant physiology and biogeochemistry. But we have as yet very little information as to the studies of seaweeds.

These elements in seaweeds are thought to have an important role in the metabolism and cycling organization in the sea. Though determination of the contents of these elements in seaweeds may be primary works for these themes, there are little reports on them.

We have analysed inorganic constituents in many sorts of seaweeds collected from a certain limited area, and have already reported of total ashes and sodium, potassium[1] and manganese[2) 3)] contents. The present paper is the results of quantitative analysis on calcium, magnesium and phosphorus in the same materials.

Experimental

Samples

Seaweeds used for the present experiments were collected at the coast of Tomoga-Shima, Wakayama Pref., Japan. Prior to analysis, the materials were washed carefully with distilled water untill the washings showed absence of chloride ions.

As for total ashes, and sodium, potassium and manganese contents in these samples the authors have already reported in other journals.[1) 2) 3)] Sample numbers were given commonly through a series of these studies.

Determination

The wet materials were dried at 40°C to 50°C. Samples were specially so selected as to avoid any contamination before use, and dried at 105°C for about

two hours. After the dried samples were weighed, they were ashed gradually at 400°C to 500°C in an electric-furnace.

Took 0.5~1.0 gr. of ashes. Dissolved with dilute hydrochloric acid, removed silicic acid as precipitate and determined calcium, magnesium and phosphorus by the following procedures[4] gravimetrically.

After adding proper amount of ferric ammonium sulfate to the above aliquot, excluded iron, aluminum and phosphorus by reprecipitation with ammonium hydroxide. Reprecipitated it with ammonium oxalate and determined calcium by calcium oxide method. Determined magnesium in the filtrate by oxine method. On the other hand, after separated Phosphorus as ammonium phosphomolybdate, determined phosphorus by magnesium pyrophosphate method with newly taken silicic-excluded hydrochloric acid solution.

Results

The results of experiments on 42 samples (30 species) were shown in Table 1, 2, 3 and 4 in the order of Brown Seaweeds (*Phaeophyceae*), Green Seaweeds (*Chlorophyceae*) and Red Seaweeds (*Rhodophyceae*). The atomic ratio of calcium to magnesium in each sample has been calculated. On *Eisenia bicyclis, Hizikia fusiforme, Sargassum Ringgoldianum, Sargassum Thunbergii* and *Acanthopeltis japonica* analysis was made with several samples.

Table 1. The Contents of Calcium, Magnesium and Phosphorus in Brown Seaweeds (1)

A....Percentage in ashes
B....Percentage in dry matter

Family	Species	No.	Date of Collection	Ca (%)		Mg (%)		P (%)		Ca/Mg (atomic ratio)
				A	B	A	B	A	B	
Encoeliagae	Myelophycus caespitosus	2	Feb. 29, '56	10.89	3.19	3.65	1.07	0.62	0.18	1.81
Desmavestiaceae	Desmarestia viridis	3	May 16, '56	22.41	0.87	0.79	0.03	2.32	0.09	17.21
Chordariaceae	Eudesme crassa	4	Oct. 16, '55	5.70	0.63	7.19	0.79	1.04	0.11	0.48
	Chordaria sp.	5	Oct. 16, '55	10.46	1.19	5.84	0.67	0.61	0.07	1.09
Laminariaceae	Eisenia bicyclis	7	May 16, '56	11.66	1.88	5.63	0.91	0.66	0.11	1.26
		8	May 26, '57	9.52	1.31	5.72	0.79	0.77	0.11	1.01
		9	Aug. 28, '56	12.54	1.78	6.98	0.99	0.45	0.06	1.09
		10	Oct. 16, '55	8.75	1.14	5.08	0.66	0.62	0.08	1.04
	(Average)			10.62	1.53	5.85	0.84	0.63	0.09	1.10
Dictyotaceae	Padina arborescens	13	May 16, '56	6.80	1.28	6.16	1.16	0.48	0.09	0.67
	Neurocarpus prolifera	17	Aug. 28, '56	13.35	1.40	5.48	0.58	1.75	0.18	1.48
Sargassaceae	Hizikia fusiforme	22	Feb. 17, '53	8.95	1.88	4.00	0.84	0.58	0.12	1.36
		25	May 16, '56	10.09	1.94	6.12	1.18	0.32	0.06	1.00
	(Average)			9.52	1.91	5.06	1.01	0.45	0.09	1.18
"	Sargassum everve	26	Oct. 16, '55	15.80	1.98	10.07	1.26	0.71	0.09	0.95
	Sargassum gigantei-folium	27	Jan. 26, '56	13.21	1.57	11.44	1.36	0.95	0.11	0.70

Table 2. The Contents of Calcium, Magnesium and Phosphorus in Brown Seaweeds (2)

A....Percentage in ashes
B....Percentage in dry matter

Family	Species	No.	Date of Collection	Ca (%)		Mg (%)		P (%)		Ca/Mg (atomic ratio)
				A	B	A	B	A	B	
Sargassaceae	Sargassum Ringgoldianum	30	May 16, '56	15.97	2.44	7.91	1.21	0.52	0.08	1.23
		32	Aug. 28, '56	17.00	2.31	7.11	0.97	0.49	0.07	1.45
	(Average)			16.49	2.38	7.51	1.09	0.51	0.08	1.34
	Sargassum serratifolium	33	Aug. 8, '55	17.79	2.92	10.04	1.65	0.09	0.02	1.07
	Sargassum piluliferum	34	Aug. 8, '55	19.76	1.90	7.11	0.68	0.75	0.07	1.69
	Sargassum Horneri	36	Jan. 26, '56	16.08	1.64	16.52	1.69	1.18	0.12	0.59
	Sargassum tortile	37	Oct. 16, '55	23.78	2.66	6.99	0.78	0.65	0.07	2.06
	Ishige Okamurai	38	Feb. 29, '56	11.92	1.48	6.80	0.84	1.36	0.17	1.06
	Sargassum micracanthum	40	Aug. 28, '56	17.62	2.41	8.58	1.18	0.36	0.05	1.24
	Sargassum Thunbergii	41	Jan. 26, '56	7.64	1.23	4.68	0.75	0.77	0.12	0.99
		42	Feb. 29, '56	12.89	2.28	3.89	0.69	0.83	0.15	2.01
		43	Mar. '54	14.71	2.87	3.86	0.75	0.47	0.09	2.31
		44	May 16, '56	13.68	2.24	6.46	1.06	0.55	0.09	1.29
		45	May 16, '56	20.53	4.21	6.25	1.28	0.38	0.08	1.99
		47	Aug. 13, '54	13.29	2.75	4.57	0.95	0.40	0.08	1.77
		50	Oct. 18, '52	17.97	3.40	4.63	0.88	0.85	0.16	2.35
	(Average)			14.39	2.71	4.91	0.91	0.61	0.11	1.82

Table 3. Tne Contents of Calcium, Magnesium and Phosphorus in Green Seaweeds

A....Percentage in ashes
B....Percentage in dry matter

Family	Species	No.	Date of Collection	Ca (%)		Mg (%)		P (%)		Ca/Mg (atomic ratio)
				A	B	A	B	A	B	
Ulvaceae	Monostroma nitidum	51	Jan. 26, '56	7.24	1.72	6.00	1.43	0.39	0.09	0.73
	Ulva conglobata	52	Aug. 28, '56	5.25	0.83	22.93	3.65	0.48	0.08	0.14
	Ulva sp.	53	Oct. 16, '55	3.42	0.57	22.81	3.83	0.71	0.12	0.09
	Ulva sp.	54	Jan. 26, '56	2.96	0.56	23.33	4.43	0.88	0.17	0.08
Cladophoraceae	Chaetomorpha crassa	58	May 16, '56	9.30	1.13	7.11	0.86	0.69	0.08	0.79
Codiaceae	Codium fragile	59	Oct. 16, '55	7.59	1.14	7.43	1.11	1.02	0.15	0.62
	Codium pugniformis	60	May 16, '56	2.40	0.86	4.28	1.54	0.77	0.28	0.34

Table 4. The Contents of Calcium, Magnesium and Phosphorus in Red Seaweeds

A....Percentage in ashes
B....Percentage in dry matter

Family	Species	No.	Date of Collection	Ca (%)		Mg (%)		P (%)		Ca/Mg (atomic ratio)
				A	B	A	B	A	B	
Gelidiales	Gelidium sp.	62	Aug. '55	10.98	0.35	15.52	0.50	0.68	0.02	0.43
	Gelidium sp.	63	Oct. 16, '55	11.69	0.77	15.78	1.04	2.38	0.16	0.45
"	Acanthopeltis	66	Aug. 28, '56	3.42	0.47	1.62	0.22	0.98	0.13	1.28
		67	Oct. 16, '55	2.91	0.31	2.36	0.25	0.75	0.08	0.75
	(Average)			3.17	0.39	1.99	0.24	0.87	0.11	1.02
Meristotheca	Meristotheca papulosa	68	Aug. 28, '56	3.76	0.62	5.10	0.84	0.81	0.13	0.45
Grateloupiaceae	Carpopeltis fiabellata	75	Mar. '55	3.82	0.38	7.89	0.78	1.24	0.12	0.29

Summary

On 42 samples composed of 30 species collected from the same habitat through every season the contents of calcium, magnesium and phosphorus have been determined.

1) The Brown Seaweeds had rich calcium contents in general and some Green Seaweeds and Red Seaweeds showed lower calcium contents than those in Brown Seaweeds.
2) In general seaweeds contain much more magnesium than the land plants, especially Ulva sp. contained much of it (4.43% was the highest in dried materials).
3) The atomic ratio of calcium to magnesium which is considered as one factor of existence condition of plants, was below 2.0 except one species (*Desmarestia viridus*).
4) The phosphorus contents in dried materials were approximately 0.1% in almost every species.

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CHEMICAL STUDIES ON THE OCEAN (Part 79)

CHEMICAL STUDIES ON THE SEAWEEDS (VII)

Iron Content in Seaweeds

By

Masayoshi Ishibashi* and Toshio Yamamoto

(*Department of Chemistry, Faculty of Science, Kyoto University)

The quantity of iron dissolving in sea water is very little. It has been found that seaweeds organisms can utilize insoluble colloidal ferric hydroxide which consists in sea water. The function of seaweeds in the cycling of iron of the sea has long attracted much interest.[1)]

On the other hand, iron, one of essential minor constituents, has an important role in plant physiology. Therefore iron in seaweeds may be attractive theme to study.

For the fundamental process in the general studies on these themes, it is necessary to know the iron contents in seaweeds, since we have as yet little knowledge on this point.

We are to know the iron contents generally in the seaweeds. In the present paper we have determined iron contents correctly of as much seaweeds as possible collected from a certain limited area through every season.

Experimental

Samples

Seaweeds used for the present experiments were collected at the coast of Tomoga-Shima, Wakayama Pref., Japan. Prior to analysis, the materials were washed carefully with distilled water untill the washings showed absence of chloride ions.

As for total ashes, and sodium, potassium,[2)] manganese,[3)] calcium, magnesium and phosphorus** contents in these samples we have already reported. Sample numbers were given commonly through a series of these studies.

Determination

The wet materials were dried at 40°C to 50°C. Samples were specially so selected as to avoid any contamination before use, and dried at 105°C for about

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** Chemical Studies on the Seaweeds (VI)

two hours. After the dried samples were weighed, they were ashed gradually at 400°C to 500°C in an electric-furnace.

Took 0.1～0.2 gr, of ashes, added 5 ml. of 1:1 hydrochloric acid and small quantity of distilled water. Warmed and evaporated it to dryness on a water-bath. Then added 10 ml. of 1:1 hydrochloric acid and warmed on a water-bath more than ten minutes until all the soluble materials had been brought into solution. Diluted with water and filtered through a small paper (previously washed with hot dilute hydrochloric acid) into a volumetric flask. Ignited the paper and its contents in a crucible at about 500°C. To the residue, added a small quantity of 1:3 hydrochloric acid. Warmed and rinsed into the volumetric flask. Diluted the solution in the volumetric flask to the mark and determined iron colorimetrically in a suitable aliquot with O- Phenanthroline Method.[1] For determining transmittancy, a filter showing maximum transmission at 500 mμ was used.

Results

The results of experiments on 72 samples (41 species) were shown in Table 1, 2, 3 and 4 in order of Brown Seaweeds (*Phaeophyceae*), Green Seaweeds (*Chlorophyceae*) and Red Seaweeds (*Rhodophyceae*). The analytical value shows mg. iron per gr. ashes and mg. iron per gr. dried material. From iron contents in ashes and previously related manganese contents,[3] the atomic ratio of iron to manganese has been calculated on 63 samples (37 species) of seaweeds. Average value among some samples of the same species has been added.

Table 1. Iron Contents in Brown Seaweeds (1)

Family	Species	No.	Date of Collection	mg. Fe per gr. of Ashes		mg. Fe per gr. of dry matter		Fe/Mn (atomic ratio)	
					Average		Average		Average
Encoeliagae	Myelophycus caespitosus	1	Jan. 26, '56	8.401	8.401	1.193	1.193	21.69	21.69
	Scytosiphon lomentarius	2	Feb. 29, '56	11.637	11.637	3.410	3.410	43.20	43.20
Desmarestiaceae	Desmarestia viridis	3	May 16, '56	10.768	10.768	0.420	0.420	47.29	47.29
Chordariaceae	Eudesme crassa	4	Oct. 16, '55	19.418	19.418	2.136	2.136	9.24	9.24
	Chordaria sp.	5	Oct. 16, '55	5.120	5.120	0.584	0.584	4.73	4.73
Laminariaceae	Eisenia bicyclis	6	Jan. 26, '56	0.656		0.106		12.18	
		7	May 16, '56	0.893		0.144		12.03	
		8	May 26, '57	0.649	0.680	0.090	0.100	23.65	13.95
		79	Aug. 1, '58	0.530		0.076			
		9	Aug. 28, '56	0.542		0.077		11.11	
		10	Oct. 16, '55	0.812		0.106		10.79	
Dictyotaceae	Padina arborescens	12	Feb. 29, '56	2.822		0.353		3.68	
		13	May 16, '56	3.418	3.759	0.643	0.568	3.20	3.87
		14	Aug. 8, '55	4.323		0.627			
		15	Aug. 28, '56	4.473		0.649		4.74	
„	Neurocarpus prolifera	17	Aug. 28, 56	8.576	8.576	0.900	0.900	12.61	12.61
Sargassaceae	Hizikia fusiforme	18	Jan. '55	1.709		0.270		6.37	
		19	Jan. 26, '56	0.747		0.133		5.36	
		20	Feb. '54	1.206	1.065	0.187	0.188	5.62	6.35
		22	Feb. 17, '53	0.535		0.112		3.93	
		24	Mar. 15, '53	1.325		0.258		8.30	
		25	May 16, '56	0.868		0.167		8.54	

Table 2. Iron Contents in Brown Seaweeds (2)

Family	Species	No.	Date of Collection	mg. Fe per gr. of Ashes	Average	mg. Fe per gr. of dry matter	Average	Fe/Mn (atomic ratio)	Average
Sargassaceae	Sargassum enerve	26	Oct. 16, '55	1.215	1.215	0.152	0.152	5.43	5.43
	Sargassum giganteifolium	27	Jan. 26, '56	1.329	1.329	0.158	0.158	11.57	11.57
	Sargassum Ringgoldianum	28	Jan. 26, '56	0.457		0.070		6.61	
		29	Jan. 26, '56	0.991		0.154		17.10	
,,		30	May 16, '56	0.738	0.656	0.113	0.097	5.85	8.40
		31	Aug. 8, '55	0.578		0.080		8.36	
		32	Aug. 28, '56	0.515		0.070		4.09	
,,	Sargassum serratifolium	33	Aug. 8, '55	0.564	0.564	0.092	0.092	25.22	25.22
,,	Sargassum Piluliferum	34	Aug. 8, '55	5.138	5.624	0.493	0.616	14.69	15.86
		35	Aug. 8, '55	6.110		0.739		17.03	
,,	Sargassum Horneri	36	Jan. 26, '56	1.397	1.397	0.142	0.142	9.75	9.75
	Sargassum tortile	37	Oct. 16, '55	1.059	1.059	0.119	0.119	5.95	5.95
	Ishige Okamurai	38	Feb. 29, '56	0.707	0.707	0.088	0.088	11.59	11.59
	Ishige foliacea	39	Feb. 29, '56	1.252	1.252	0.144	0.144	4.61	4.61
	Sargassum micracanthum	40	Aug. 28, '56	2.676	2.676	0.367	0.367	3.02	3.02
	Sargassum Thunbergii	41	Jan. 26, '56	5.050		0.813		3.11	
		42	Feb. 29, '56	3.728		0.660		2.76	
		43	Mar. '54	9.922		1.935		6.23	
		44	May 16, '56	4.236	4.623	0.695	0.856	3.71	3.46
,,		45	May 16, '56	1.418		0.291		2.85	
		46	Aug. 8, '55	6.116		1.089		6.22	
		47	Aug. 13, '54	5.812		1.203		2.48	
		49	Oct. 16, '55	3.011		0.584		2.19	
		50	Oct. 18, '52	2.316		0.438		2.55	

Table 3. Iron Contents in Green Seaweeds

Family	Species	No.	Date of Collection	mg. Fe per gr. of Ashes	Average	mg. Fe per gr. of dry matter	Average	Fe/Mn (atomic ratio)	Average
Ulvaceae	Monostroma nitidum	51	Jan. 26. '56	6.024	6.024	1.434	1.434	25.54	25.54
	Ulva conglobata	52	Aug. 28, '56	3.828	3.828	0.609	0.609	6.14	6.14
	Ulva sp.	53	Oct. 16, '55	2.975	2.975	0.500	0.500	2.93	2.93
"	Ulva sp.	54	Jan. 26, '56	2.767	2.409	0.526	0.445	42.53	42.53
		80	Aug. 1, '58	2.050		0.363			
"	Ulva sp	55	Oct. 16, '55	2.653	2.653	0.334	0.334	2.96	2.96
Cladophoraceae	Cladophora Wrightiana	56	Oct. 16, '55	3.233	3.233	0.582	0.582	6.54	6.54
"	Chaetomorpha crassa	57	Jan. 26, '56	3.691	4.166	0.376	0.469	3.63	3.20
		58	May 16, '56	4.640		0.561		2.77	
Caulerpa	Cavlerpa Okamurai Weber	81	Aug. 1, '58	16.920	16.920	3.079	3.079		
Codiaceae	Codium fragile	59	Oct. 16, '55	16.648	16.648	2.497	2.497	8.23	8.23
	Codium pugniformis	60	May 16, '56	1.642	1.642	0.591	0.591	11.14	11.14

Table 4. Iron Contents in Red Seaweeds

Family	Species	No.	Date of Collection	mg. Fe per gr. of Ashes		mg. Fe per gr. of dry matter		Fe/Mn (atomic ratio)	
					Average		Average		Average
Gelidiales	Gelidum sp.	62	Aug. '55	7.014	7.014	0.224	0.224	5.36	5.36
,,	Gelidum sp.	82	Aug. 1, '58	8.750	6.309	0.534	0.395		
		63	Oct. 16, '55	3.867		0.255		3.56	3.56
,,	Acanthopeltis japonica	64	Jan. 26, '56	2.111	1.903	0.293	0.238	3.62	3.92
		67	Oct. 16, '55	1.695		0.183		4.32	
Meristotheca	Meristotheca papulosa	68	Aug. 28, '56	2.838	2.838	0.465	0.465	1.36	1.36
Sphaerococcacede	Sarcodia ceylanica	69	Feb. 29, '56	3.427	3.427	0.343	0.343	7.01	7.01
	Hypnea Saidana	70	Jan. 26, '56	3.853	3.853	0.424	0.424		
	Hypnea sp.	71	Jan. 26, '56	6.174	6.174	1.013	1.013		
Plocamiaceae	Plocamium Telfairiae	72	Jan. 26, '56	7.557	7.557	1.504	1.504		
Grateloupiaceae	Carpopeltis flabellata	75	Mar. '55	2.234	1.772	0.221	0.180	7.76	7.76
		83	Aug. 1, '58	1.310		0.139			
Rhizophyllidaceae	Chondrococcus japonicus	77	Oct. 16, '55	8.592	8.592	1.091	1.091	3.97	3.97
	Zostera Marina	78	Oct. 16, '55	7.351	7.351	1.235	1.235	6.26	6.26

Summary

On 72 samples composed of 41 species, collected from the same habitat through every season have been determined iron contents, and atomic ratio of iron to manganese has been calculated among above-mentioned seaweeds.

1) Iron contents in dried seaweeds were from 3.410 mg to 0.070 mg per gr. There was considerable difference among species.
2) In general Green Seaweeds were high in iron contents. In contrast with them several Brown Seaweeds belonging to the Sargassaceae family had low iron contents.
3) Those species (e. g. *Myelophycus caespitasus, Caulerpa Okamurai Weber, Scytosiphon Lomentarius* and *Monostroma nitidum*) which were collected from shallow sea were rich in the iron contents.
   Those species (e.g. *Eisenia bicyclis, Sargassum Riggoldianum* and *Sargassum serratifolium*) which are large and intricate were generally poor in the iron contents.
4) In general, seaweeds which had high manganese contents had also high iron contents, and those which were low in iron contents wer low in manganese contents too.
5) Approximately half of the analysed species showed the value of 3~7 in the atomic ratio of iron to manganese. In the same species of seaweeds close values were found in the atomic ratio of iron to manganese commonly.

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CHEMICAL STUDIES ON THE OCEAN (Part 82)

CHEMICAL STUDIES ON THE SEAWEEDS

Quantitative Determination of Beryllium in Seaweeds

By

Masayoshi Ishibashi, Taitiro Fujinaga and Tooru Kuwamoto

(Chemistry Institute, Faculty of Science, Kyoto University)

Quantitative determination of beryllium in sea-weeds has not yet been reported before. In the present paper, the authors report on the determination of beryllium present in sea-weed (*Eisenia bicyclis*) using spectrograph with intermittent arc.

As the result, it was found that 10^{-8} μg beryllium was present per gram of the sea-weed.

Experimentals

Spectrophotometer: Photometric spectrometer (Shimadzu Co. Ltd.) was used.

Spectrograph: Medium spectrograph (Adam Hilger Co. Ltd.) was used with Shimadzu intermittent arc source.

Sample: The sea-weed was collected at the shore of Tomogashima, Wakayama Pref. Japan on 1st Aug. 1958. The sample was thoroughly washed with distilled water and dried at 105°C.

Separation of beryllium from calcium and magnesium: As in the case of the determination of strontium[1], the artificially synthesized ash solution was prepared. 20~30 mg of aluminium ions are added as carriers to the sample solution (equivalent to 10g-ash) and the pH was adjusted to 5.0 with ammonia water. By the procedure, the beryllium was found to coprecipitate quantitatively with aluminium phosphate, remaining most of calcium and magnesium in the solution. (cf. Table 1.)

Separation of phosphate from beryllium: After the addition of nitric acid and ammonium nitrate to the solution, ammonium molybdate was added to precipitate phosphate ions[2] and the pH of the filtrate was adjusted to pH = 7.0. By the procedure beryllium ions were found to coprecipitate quantitatively with aluminium hydroxide. (cf. Tables 2 and 3.)

Extraction of beryllium from aluminium[3]: The precipitate of beryllium and aluminium hydroxide was dissolved in hydrochloric acid and 40 ml of 10% EDTA solution was added to mask aluminium ions from extraction. After adjusting the pH to 7.0, 5 ml of 5% acetyl acetone was added, shaken and stood

Table 1. Coprecipitation* of beryllium with ferric phosphate (in artificial ash)

No.	pH	Be^{++} added (μg)	Al^{+++} (mg)	Be^{++} found (μg)	Recovery (%)
1	5.0	5.0	50	5.0	100
2	4.5	5.0	50	4.9	98
3	4.0	5.0	50	4.8	96
4	5.0	5.0	10	4.6	92
5	4.5	5.0	10	5.1	102
6	4.0	5.0	10	4.3	86

*Artificial ash used in the experiment (according to the data of Ishibashi)

NaCl	35.3g	$CaCO_3$	24.0 g	KCl	13.4
H_3PO_4	1.2	$FeCl_3$	0.17	$MgCl_2 \cdot 6aq$	50.2

Table 2. Effect of phosphate to the extraction

No.	Be^{++} added (μg)	A.A.T.*	E D T A**	H_3PO_4 (mg)	Be^{++} found (μg)	Recovery (%)
1	5.0	1%— 2ml	1%— 2ml	1 000	—	—
2	5.0	1%— 2ml	1%— 2ml	100	4.35	87
3	5.0	1%— 2ml	1%— 2ml	50	4.7	94
4	5.0	1%— 2ml	1%— 2ml	10	5.1	102
5	5.0	5%—10ml	10%—60ml	250	4.9	98
6	1.0	5%—10ml	10%—60ml	250	0.95	95
7	5.0	5%—10ml	10%—60ml	500	4.8	96
8	5.0	5%—10ml	10%—60ml	1 000	0.2	4
9	5.0	5%—10ml	10%—60ml	2 000	0.3	6

*Acetylacetone
**Ethylendiaminetetraaceticoacid

Table 3. Coprecipitation of beryllium with ferric hydroxide (pH 7.0)

No.	Be^{++}added (μg)	Al^{+++} (mg)	Be^{++}found (μg)	Recovery (%)
1	2.0	10	1.9	95
2	2.0	10	2.0	100
3	2.0	50	1.8	90
4	5.0	50	4.8	96
5	2.0	100	2.0	100
6	5.0	100	4.6	92

for 5 minutes. The extraction with chloroform was repeated three times. By the procedure, beryllium was found to be separated quantitatively from aluminium (cf. Table 4.)

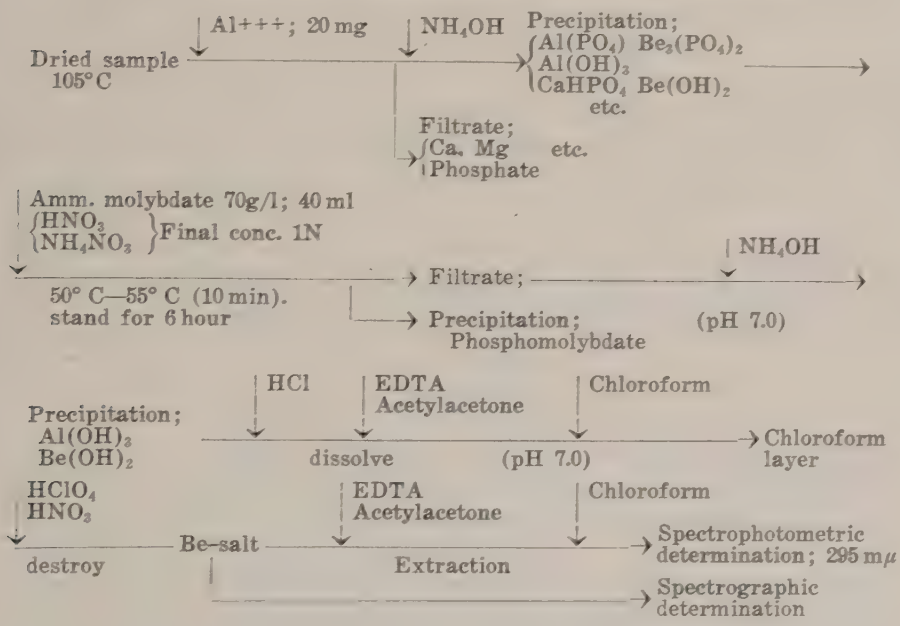
Determination of beryllium in sea-weed: According to the results obtained by the foregoing experiments, the determination of beryllium in sea-weed was performed by the scheme demonstrated in Fig. 1.

Table 4. Separation of beryllium in the large amounts of aluminium

No.	Al^{+++} (mg)	Be^{++} added (μg)	Be^{++} found (μg)	Recovery (%)
1	200	1.5	1.6	106
2	200	1.5	1.35	90
3	200	3.0	2.85	95
4	200	5.0	4.75	95
5	200	5.0	4.7	94
6	300	1.5	1.65	110
7	300	1.5	1.7	113

Separation; Acetylacetone 5 %—10 ml
E D T A 10 %—60 ml
Determination; Acetylacetone 1 %— 2 ml
E D T A 10 %— 2 ml

Fig. 1. Scheme of the determination of beryllium in sea-weed



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CHEMICAL STUDIES ON THE OCEAN (Part 83)

CHEMICAL STUDIES ON THE SEAWEEDS

Quantitative Determination of Strontium in Seaweeds

By
Masayoshi Ishibashi, Taitiro Fujinaga, Tooru Kuwamoto and
Takahiro Kumamaru
(Chemistry Institute, Faculty of Science, Kyoto University)

Recently, Black[1] et al reviewed on the analytical studies of inorganic components contained in sea-weeds and also reported on the qualitative analysis of strontium in sea-weeds using emission spectroscopic method.

Previously, Ishibashi and co-workers[2][3] have reported a series of studies on the qualitative and quantitative determination of traces of inorganic elements in sea-weeds. In the present paper, the authors report on the method of quantitative determination of strontium, which was applied to the analysis of a sea-weed (*Eisenia bicyclis*).

As the result, the strontium content in the sea-weed was determined to be 0.53～0.73 mg per gram of dried sample. Comparing the data with those of sea water, it is concluded that strontium is more concentrated than calcium in the sea-weed.

Experimentals

Sample: The sea-weed (*Eisenia bicyclis*) was collected at the shore of Tomogashima, Wakayama Pref., Japan on 1st August 1958. The sample was washed with distilled water until no chloride ions are detected in the waste and dried at 105°C to give constant weight.

Experiments: Much quantity of phosphate being present in biological materials, the removal of phosphate is necessary before determining strontium. As the preliminary experiments, a synthesized ash sample solution was prepared, which contained 10 mg of phosphate, 6 mg of calcium, 4 mg of magnesium, 6 mg of ferric iron, and 3 mg of aluminium ions in 50 ml of 1N-hydrochloric acid.

After thorough investigation, it was made clear that by the control of the pH of the solution at 4.5 to 5.0, all iron and aluminium precipitate as phosphate[4], remaining alkaline earth ions quantitatively in the supernatant solution.

Then the calcium ions in the supernatant solution were precipitated as oxalate and the precipitate was dissolved in 6N-hydrochloric acid and diluted with distilled water.

To the solution were added 70 ml of methanol and 7 ml of dimethyl sulphate and allowed to stand for one hour on the water bath. By the procedure[5], the strontium was quantitatively precipitated as sulphate with a portion of calcium coprecipitated.

For the separation of strontium from calcium, the cation exchange resin Dowex-50X8 (150~200 mesh) was utilized. For the elution of the strontium ions, the mixture[6] of ammonium acetate and acetic acid was used. The distribution coefficients of both calcium and strontium were determined by the batch method, whose results are shown in Table 1.

Table 1. Distribution coefficients of strontium and calcium

Eluent	2 N-A mm. Acetate		2 N—A mm. Acetate +Acetic acid							
pH	7.3		6.5		5.5		5.0		4.6	
	K_d^{Sr}/K_d^{Ca}	K_d^{Ca}	K_d^{Sr}/K_d^{Ca}	K_d^{Ca}	K_d^{Sr}/K_d^{Ca}	K_d^{Ca}	K_d^{Sr}	K_d^{Ca}	K_d^{Sr}/K_d^{Ca}	K_d^{Ca}
Concentration (N)										
1.0	2.10	18.7	1.99	13.2	1.60	21.2	1.77	16.2	—	—
1.2	1.65	13.2	1.07	18.7	2.10	14.2	2.72	9.2	—	—
1.4	2.48	8.4	1.27	12.7	2.40	8.2	3.56	6.2	4.17	5.7
1.6	3.46	5.6	1.40	7.4	2.44	7.5	4.06	4.6	5.36	5.0

As is seen from Table 1, it is recommended to use 1.6N-ammonium acetate and acetic acid at pH=4.6 as the effluent.

This ion exchange method was applied to the separation of strontium from calcium; 0~200 mg of calcium ions and 0~30 mg of strontium ions were adsorbed on the column (2×26.5 cm) contained with Dowex-50X8 and the effluent was passed through at the flow rate of 1.0~1.5 ml per minute.

The results of separation are shown in Fig. 1. and also in Table 2.

Table 2. Separation of calcium and strontium

No.	Taken (mg)		Mole ratio	Found (mg)		Error (%)	
	Ca	Sr	Ca/Sr	Ca	Sr	Ca	Sr
1	199.43	2.00	219	199.12	2.01	−0.2	+0.5
2	199.43	10.00	44	200.01	9.95	+0.3	−0.5
3	179.08	30.00	13	179.53	30.10	+0.3	+0.3
4	97.68	5.00	43	97.57	5.02	−0.1	+0.4
5	28.49	10.00	6	28.40	10.00	−0.3	0

Determination of strontium in artificial ash sample: According to the data of the analysis of the sea-weed ash, an artificially synthesized ash sample was prepared, whose composition is reproduced in Table 3.

The amount of strontium determined by the procedure given in Fig. 2, showed good agreement with the amount of strontium added within 3%. (Table 4)

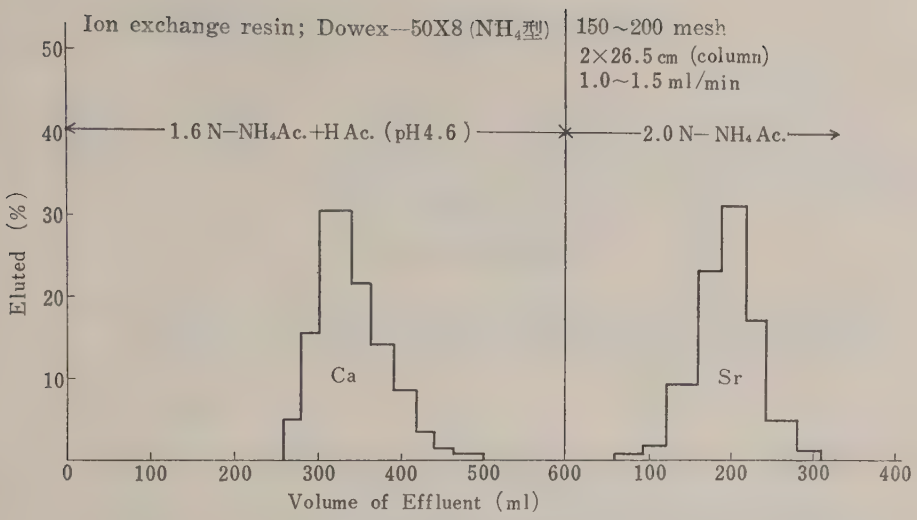


Fig. 1. Elution curve of the mixture of calcium and strontium

Table 3. Artificial ash used in the experiment
(according to the data of Ishibashi et al.)

NaCl	35.3 g	$CaCO_3$	24.0 g	KCl	13.4 g
H_3PO_4	1.2 g	$FeCl_3$	0.17 g	$MgCl_2 \cdot 6aq$	50.2 g

Table 4. Determination of strontium in artificial ash

No.	Taken (mg)	Found (mg)	Error (%)
1	5.00	5.07	+1.4
2	10.00	9.68	−3.1
3	10.00	9.71	−2.9
4	20.00	19.64	−1.8
5	30.00	30.20	+0.7
6	30.00	29.74	−1.0

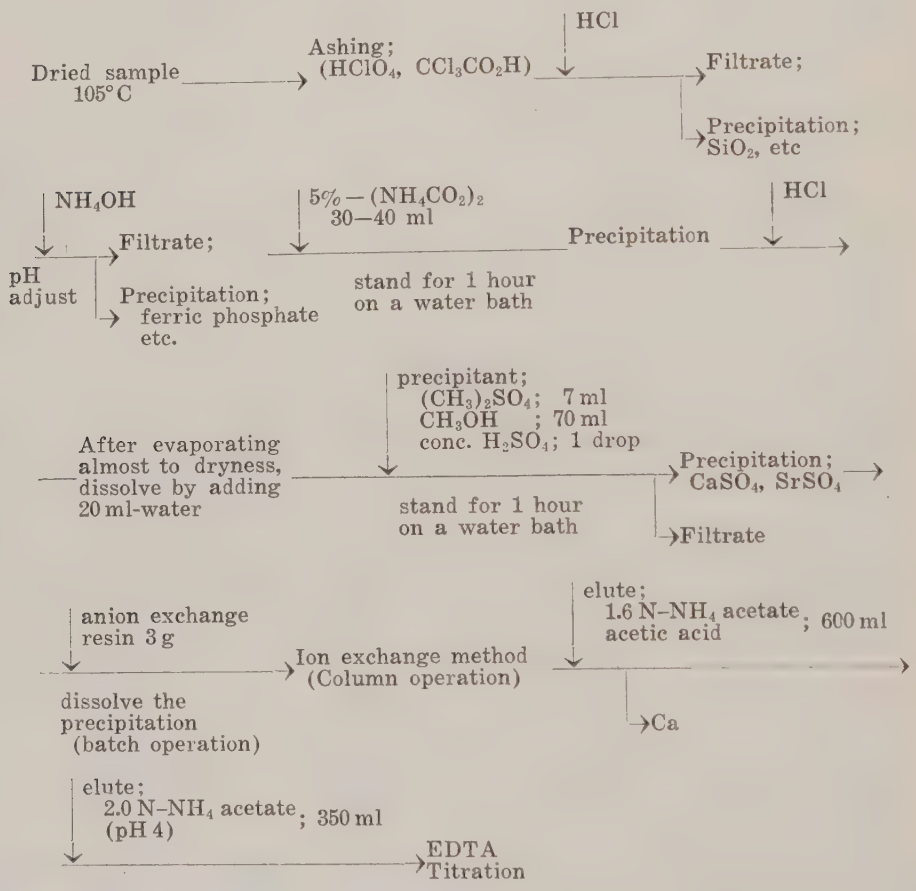
Determination of strontium in the sea-weed (*Eisenia bicyclis*): About 25.0 g of the sample sea-weed dried at 105°C was weighed. 300 ml of 60% perchloric acid—Trichloro-acetic acid (10:1) was poured to the sample and heated gently on the hot plate to decompose it. After almost to dryness, 10 ml of conc. hydrochloric acid was added, dried again and diluted with distilled water. After filtration, the solution was then analysed according to the procedure given in Fig. 2.

The results are shown in Table 5.

Table 5. Strontium content in sea-weed (*Eisenia bicyclis*)

Collected Date	Found (mg/g dried sample)			
	I	II	III	Mean
Aug. 28. 1956	0.726	0.712	0.722	0.720
Aug. 1. 1958	0.519	0.530	0.525	0.525

Fig. 2. Scheme of the determination of strontium in sea-weed


Dried sample 105°C
Ashing; ($HClO_4$, CCl_3CO_2H)
HCl
Filtrate;
Precipitation; SiO_2, etc
NH_4OH
Filtrate;
pH adjust
Precipitation; ferric phosphate etc.
5% — $(NH_4CO_2)_2$ 30—40 ml
stand for 1 hour on a water bath
Precipitation
HCl
precipitant; $(CH_3)_2SO_4$; 7 ml CH_3OH ; 70 ml conc. H_2SO_4; 1 drop
After evaporating almost to dryness, dissolve by adding 20 ml-water
stand for 1 hour on a water bath
Precipitation; $CaSO_4$, $SrSO_4$
Filtrate
anion exchange resin 3 g
Ion exchange method (Column operation)
dissolve the precipitation (batch operation)
elute; 1.6 N-NH_4 acetate acetic acid ; 600 ml
Ca
elute; 2.0 N-NH_4 acetate (pH 4) ; 350 ml
EDTA Titration

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BASIC STUDIES ON THE ANALYSIS AND THE SEPARATION OF BORIC ACID

(2nd Report)

On the Complex Precipitate of Barium Boro Manno Saccharate and Barium Boro Aravotrihydroxyglutarate

By

Masayoshi Ishibashi, Koichi Emi, Takeshi Kusaka and Mitsuyuki Mitooka

(Faculty of Science, Kyoto University and Faculty of Science, Okayama University)

Introduction

An excellent method for the determination of small amount of boric acid was already reported. However, boron can not be separated or purified without many difficult procedures.

If boron precipitates as a boron-high molecular compound complex, it will contribute not only to the gravimetric analysis, but also to the quantitative separation of boron.

This experiment was carried out so that boron might be precipitated as a complex by addition of barium salt and hydroxy carboxylic acid.

Experiment

Reagent

Manno saccharic acid (abbreviation: M. S.), 0.015M.
Aravotrihydroxy glutaric acid (abbreviation: A. T. G.), 0.05M, 0.04M, 0.03M.
Barium chloride, reagent grade, purified by recrystallization, 0.1M.
Boric acid, reagent grade, 0.5M, 0.3M, 0.1M, 0.05M.
Ammonium chloride, reagent grade, 4M.
Ammonium hydroxide, 2N.
Acetic acid, 0.6N.
Ethyl alcohol, 99%.

Experimental Method

1. Principle of analytical method

Barium hydroxy carboxylate is scarcely soluble in water, but fairly soluble in ammonium chloride-ammoniacal buffer solution. In such a buffer solution, if boric acid is added to a mixture of hydroxy carboxylic acid and barium

chloride, a complex, consisting of hydroxy carboxylic acid, boron and barium is formed.

2. Experimental procedure

4.0~6.0 ml of 0.1M barium chloride solution was mixed with 4.0 ml of 4M ammonium chloride and 1.0 ml of 2N ammonium hydroxide solution in a test tube (pH of the mixed solution is 8.80~9.00). The solution was thoroughly agitated, added 4.0 ml of hydroxy carboxylic acid or boric acid solution, and then allowed to stand for 10 minutes. After it was ascertained that the two component compound was not precipitated, the white three component complex was precipitated, by adding 0.5~4.0 ml of boric acid or hydroxycarboxylic acid. The precipitate was allowed to stand for about 5~24 hrs., filtered through glass filter (G-4, G-5) by suction, washed, dried in air bath at 120°C for 3~5 hrs. and weighed.

Conditions of Formation of two Component Precipitate

1. When ethyl alcohol is not added.

(1) On the precipitation of barium borate

Effect of pH upon the precipitation of barium borate was studied. (Table 1)

Table 1. Effect of pH upon the precipitation of barium borate

i) In 0.5M H_3BO_3

NH_4Cl(4M)	NH_4OH(2N)	$BaCl_2$(0.1M)	H_3BO_3(0.5M)	pH	ppt	Remark
ml	ml	ml	ml			
7.0	0.5	3.8	2.0	8.30	×	
7.0	0.8	3.9	2.0	8.50	×	
7.0	1.0	4.0	2.0	8.60	×	
7.0	1.5	4.3	2.0	8.78	×	
7.0	2.0	4.5	2.0	8.90	×	
7.0	2.5	4.8	2.0	9.00	×	
7.0	3.0	5.0	2.0	9.18	×	
7.0	3.5	5.3	2.0	9.22	+	white turbid after a little white
7.0	4.0	5.5	2.0	9.28	+	„
7.0	5.0	6.0	2.0	9.42	+	white turbid immediately
7.0	6.0	6.5	2.0	9.50	+	„
7.0	7.0	7.0	2.0	9.62	+	„
7.0	8.0	7.5	2.0	9.68	+	„
7.0	10.0	8.5	2.0	9.78	++	„
7.0	12.0	9.5	2.0	9.87	++	„

ii) In 0.3M H_3BO_3

NH_4Cl(4M)	NH_4OH (2N)	$BaCl_2$(0.1M)	H_3BO_3(0.3M)	pH	ppt	Remark
ml	ml	ml	ml			
7.0	0.5	3.8	2.0	8.30	×	
7.0	0.8	3.9	2.0	8.50	×	
7.0	1.0	4.0	2.0	8.60	×	
7.0	1.5	4.3	2.0	8.78	×	
7.0	2.0	4.5	2.0	8.90	×	
7.0	2 5	4.8	2.0	9.00	×	
7.0	3.0	5.0	2.0	9.18	×	
7.0	3.5	5.3	2.0	9.22	×	
7.0	4.0	5.5	2.0	9.28	×	
7.0	5.0	6.0	2.0	9.42	×	
7.0	6.0	6.5	2.0	9.50	+	white turbid after 24hrs.
7.0	7.0	7.0	2.0	9.62	+	„
7.0	8.0	7.5	2.0	9.68	+	white turbid after a little white
7.0	10.0	8.5	2.0	9.78	+	„
7.0	12.0	9.5	2.0	9.87	+	„

(2) On the precipitation of barium mannosaccharate

Effect of pH upon the precipitation of barium manno saccharate was studied. (Table 2)

Table 2. Effect of pH upon the precipitation of barium manno saccharate

NH_4Cl(4M)	NH_4OH (2N)	$BaCl_2$(0.1M)	Manno saccharic acid	pH	ppt	Remark
ml	ml	ml	ml			
7.0	0.5	3.8	2.0	8.30	×	
7.0	0.8	3.9	2.0	8.50	×	
7.0	1.0	4.0	2.0	8.60	×	
7.0	1.5	4.3	2.0	8.78	×	
7.0	2.0	4.5	2.0	8.90	+	slightly white turbid after 1hr.
7.0	2.5	4.8	2.0	9.00	+	Ca. 1mg ppt.
7.0	3.0	5.0	2.0	9.18	+	
7.0	3.5	5.3	2.0	9.22	+	
7.0	4.0	5.5	2.0	9.28	+	
7.0	5.0	6.0	2.0	9.42	+	
7.0	6.0	6.5	2.0	9.50	+	
7.0	7.0	7.0	2.0	9.62	+	
7.0	8.0	7.5	2.0	9.68	+	
7.0	10.0	8.5	2.0	9.78	+	
7.0	12.0	9.5	2.0	9.87	+	

(3) On the precipitation of barium aravotrihydroxy glutarate

Effect of different buffer solution upon the precipitation of barium aravotrihydroxy glutarate was studied.

Table 3. Ammonium chloride-Ammonium hydroxide system

NH_4Cl(4M)	NH_4OH (2N)	$BaCl_2$ (0.1M)	A. T. G. (0.03M)	pH	ppt	Remark
ml	ml	ml	ml			
5.0	1.0	3.0	3.0	8.90	—	
4.0	1.0	3.0	3.0	9.01	—	
3.0	1.0	3.0	3.0	9.12	·	
2.0	1.0	3.0	3.0	9.25	+	ppt by 2.0ml of A. T. G.
1.0	1.0	3.0	3.0	9.55	++	ppt by 1.0ml of A. T. G.

— no ppt · trace + a little ++ much +++ very much

Table 4. Acetic acid-Ammonium hydroxide system

CH_3COOH (0.6N)	NH_4OH (2N)	$BaCl_2$ (0.1M)	A. T .G. (0.03M)	pH	ppt	Remark
ml	ml	ml	ml			
3.0	1.0	3.0	3.0	9.12	++	white turbid immediately
5.0	1.8	3.0	3.0	9.35	+++	„
4.0	1.5	3.0	3.0	9.40	++	„
2.0	1.0	3.0	3.0	9.72	++	„
1.0	1.0	3.0	3.0	10.22	++	„

As shown in Tables 3 and 4, the buffer solution has a great effect upon the precipitation of barium aravotrihydroxy glutarate and the barium salt deposits easily in acetic acid-ammonium hydroxide system. Therefore, it was concluded that acetic acid-ammoniacal solution should not be used for buffer solution.

2. When ethyl alcohol is added

In this experiment, 30% ethyl alcohol was used for washing the precipitate. The solution became turbid immediately when the washings were poured into the filtrate. The precipitate having an appearance of the three component complex was produced when the turbid compound was allowed to stand for a little while. This compound being analyzed, it was confirmed that this was the three component complex precipitate. It is desirable that the two component compound such as barium borate or barium aravotrihydroxyglutarate will not be precipitated by the addition of ethyl alcohol, so that it was tested whether the salt will be precipitated or not in ethyl alcohol solution.

(1) Effect of concentration and added amount of ethyl alcohol

i) In case of 99% ethyl alcohol

The results are shown in Table 5.

Table 5. Precipitation of barium hydroxide in 99% ethyl alcohol

NH_4Cl (4M)	NH_4OH (2N)	$BaCl_2$ (0.1 M)	C_2H_5OH (99%)	ppt	Remark
ml	ml	ml	ml		
4.0	1.0	2.0	1.0	·	after 16 hrs.
4.0	1.0	2.0	3.0	+	white turbid after 12 hrs.
4.0	1.0	2.0	5.0	++	1 hr.
4.0	1.0	2.0	7.0	+++	1 hr.

ii) In case of 30% ethyl alcohol

The results are shown in Table 6.

Table 6. Precipitation of barium hydroxide and barium borate in 30% ethyl alcohol

NH_4Cl (4M)	NH_4OH (2N)	$BaCl_2$ (0.1M)	H_3BO_3 (0.5M)	C_2H_5OH (30%)	pH	ppt	
ml	ml	ml	ml	ml		1 Component	2 Component
4.0	1.0	4.0	4.0	0.0	8.79	—	—
4.0	1.0	4.0	4.0	1.0	8.72	—	·
4.0	1.0	4.0	4.0	3.0	8.70	—	·
4.0	1.0	4.0	4.0	5.0	8.65	—	+
4.0	1.0	4.0	4.0	7.0	8.62	—	+
4.0	1.0	4.0		10.0	8.61	·	/
4.0	1.0	4.0		15.0	8.59	·	/

iii) In case of 25% ethyl alcohol

The results are shown in Table 7.

Table 7. Precipitation of barium hydroxide and barium borate in 25% ethyl alcohol

NH_4Cl (4M)	NH_4OH (2N)	$BaCl_2$ (0.1M)	H_3BO_3 (0.5M)	C_2H_5OH (25%)	ppt	
ml	ml	ml	ml	ml	1 Component	2 Component
4.0	1.0	2.0	2.0	1.0	—	—
4.0	1.0	2.0	2.0	3.0	—	—
4.0	1.0	2.0	2.0	5.0	—	—
4.0	1.0	2.0	2.0	7.0	—	—

From the above data, it was found that in case of 99% ethyl alcohol, barium hydroxide is precipitated even by adding small amount of ethyl alcohol. In case of 30% ethyl alcohol, barium hydroxide is not precipitated even by adding

7.0 ml of ethyl alcohol if it is allowed to stand for 3 hours, but in the case of more than 3 hours it will be precipitated unless not more than 3.0 ml of ethyl alcohol are added. Moreover, with 25% ethyl alcohol, both one component and two component precipitates are not produced by adding not more than 5.0~7.0 ml of ethyl alcohol. Similarly, the same experiment as that of ethyl alcohol was carried out by adding acetone, and the same results were obtained.

(2) Effect of an amount of barium chloride

In the above-mentioned experiment, 2.0~4.0 ml of 0.1M barium chloride were added, but when more than 2.0~4.0 ml of barium chloride were used, the following results were obtained.

i) Precipitation of barium hydroxide

The results are shown in Table 8.

Table 8. Precipitation of barium hydroxide

NH_4Cl(4 M)	NH_4OH(2 N)	$BaCl_2$(0.1M)	C_2H_5OH(25%)	ppt		Remarks
ml	ml	ml	ml	5 hrs	24 hrs	
4.0	1.0	4.0	3.0	—	•	
4.0	1.0	8.0	3.0	—	•	
4.0	1.0	10.0	3.0	•	•	$BaCO_3$ppt

ii) Precipitation of barium borate

The results are shown in Table 9.

Table 9. Precipitation of barium borate

NH_4Cl(4 M)	NH_4OH(2 N)	$BaCl_2$(0.1 M)	H_3BO_3 (0.5 M)	C_2H_5OH(25%)	ppt
ml	ml	ml	ml	ml	5 hrs
4.0	1.0	4.0	2.0	3.0	—
4.0	1.0	4.0	4.0	3.0	—
4.0	1.0	8.0	1.0	3.0	—
4.0	1.0	8.0	2.0	3.0	•
4.0	1.0	8.0	4.0	3.0	+
4.0	1.0	10.0	1.0	3.0	+

Conditions of Formation of Three Component Precipitate

Bearing in mind the conditions of formation of two component precipitate which were already studied, three component precipitate was formed and various factors which have influences upon its precipitation were researched.

1. On the precipitation of barium boro manno saccharate

(1) Effect of pH upon the complex precipitation of barium boro manno saccharate

Amounts of barium boro manno saccharate caused by different pH are shown in Table 10.

Table 10. Effect of pH on the complex precipitation of barium boro manno saccharate (0.3M Boric acid and 0.015M manno saccharic acid were added in order of boric acid and manno saccharic acid)

NH_4Cl(4 M)	NH_4OH(2 N)	$BaCl_2$(0.1 M)	M.S.(0.015 M)	H_3BO_3(0.3 M)	pH	ppt
ml	ml	ml	ml	ml		
7.0	0.5	3.8	2.0	2.0	8.30	—
7.0	0.8	3.9	2.0	2.0	8.50	12.0
7.0	1.0	4.0	2.0	2.0	8.60	11.8
7.0	1.5	4.3	2.0	2.0	8.78	14.1
7.0	2.0	4.5	2.0	2.0	8.90	16.0
7.0	2.5	4.8	2.0	2.0	9.00	17.3
7.0	3.0	5.0	2.0	2.0	9.18	—
7.0	3.5	5.3	2.0	2.0	9.22	22.0
7.0	4.0	5.5	2.0	2.0	9.28	22.2
7.0	5.0	6.0	2.0	2.0	9.42	24.3
7.0	6.0	6.5	2.0	2.0	9.50	25.3
7.0	7.0	7.0	2.0	2.0	9.62	27.3
7.0	8.0	7.5	2.0	2.0	9.68	28.0
7.0	10.0	8.5	2.0	2.0	9.78	29.5
7.0	12.0	9.5	2.0	2.0	9.87	30.3

From Table 10, it was found that an amount of the precipitate increases with increase of the value of pH.

It was concluded that the three component complex should be precipitated in the pH range of 8.6 to 8.8, bearing in mind the precipitations of barium borate and barium manno saccharate as already stated.

(2) Effect of ethyl alcohol

The amount of the precipitate is fairly increased by the addition of ethyl alcohol, but the two component complex (chiefly barium manno saccharate and barium hydroxide) is precipitated if large excess of ethyl alcohol is added. It is, therefore, necessary to determine how much ethyl alcohol is added. From the result of this experiment, it was decided that 1 ml of 50% ethyl alcohol was the suitable amount to be added. Then, the increased amount of the precipitate owing to the addition of ethyl alcohol was studied, compared with the amount of the precipitate in case of no addition of ethyl alcohol. The results are shown in Table 11.

In case of the addition of ethyl alcohol, boric acid is detectable even in its very diluted solution.

2. On the precipitation of barium boro aravotrihydroxy glutarate

(1) Effect of time of standing

The results are shown in Table 12 and Fig. 1.

It seemed that the precipitate was formed slowly, but it was almost brought to complete precipitation in about five hours, and it is in danger of co-precipita-

Table 11. Effect of 50% ethyl alcohol upon the precipitation of barium boro manno saccharate (Addition of 1 ml of 50% ethyl alcohol)

H_3BO_3(0.3 M)	ppt (mg)		Boron found (mg)	
ml	I	II	I	II
0.7	17.7	26.4	0.343	0.507
0.5	16.7	24.7	0.349	0.474
0.4	15.9	24.1	0.329	0.461
0.3	14.2	22.0	0.290	0.435
0.2	11.5	17.5	0.231	0.336
0.1	9.2	14.3	0.171	0.270
0.07	5.8	9.9	0.114	0.195
0.05	4.7	6.6	0.093	0.130

I: C_2H_5OH was not added. II: C_2H_5OH was added.

Table 12. Time of complete precipitation

Time of standing	ppt		Condition for precipitation	
hr	mg	%		ml
0.5	18.4	87.20	NH_4Cl (4 M)	4.0
1.0	19.6	92.90	NH_4OH (2 N)	1.0
2.0	19.9	94.32	$BaCl_2$ (0.1 M)	4.0
3.0	20.1	94.78	H_3BO_3 (0.5M)	4.0
5.0	19.6	92.90	A.T.G. (0.05 M)	5.0
24.0	21.1	100.00	pH	8.80

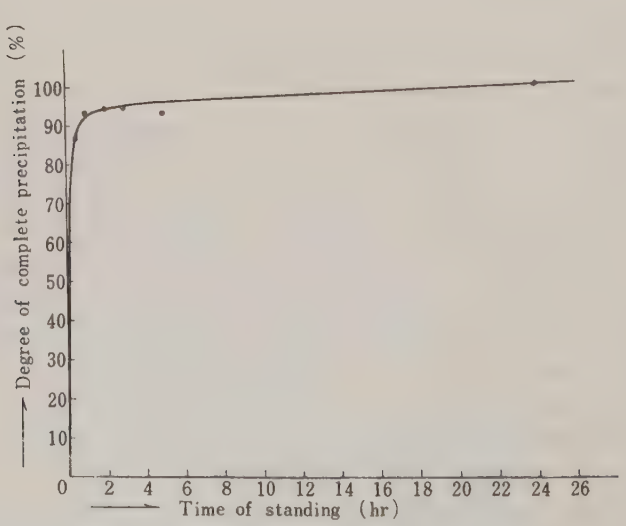

Fig. 1. Time of complete precipitation

tion of two component precipitate after 24 hours. For this reason, in later experiment, five hours were taken for ageing of the precipitate.

(2) Effect of pH

The amount of the precipitate formed at various pH values in less than 8.80 range was studied, except for the range of formation of two component precipitate (pH>8.80). (Table 13, Fig. 2)

Table 13. Effect of pH upon the amount of the precipitate

Ex. No.	ph	Turbidity	ppt (mg)	Condition for precipitation	ml
1	8.39	white turbid after for 1 hr.	0.4	NH_4Cl (4 M)	Ex. No. 1 : 5.0 2 : 4.0 3 : 5.0 4 : 4.0
2	8.50	„ 10 min	2.3	NH_4OH (2 N)	1 : 0.5 2 : 0.5 3 : 1.0 4 : 1.0
3	8.69	„ 5 min	3.5	$BaCl_2$ (0.1 M)	4.0
4	8.80	ppt immediately after 1 hr.	9.0	H_3BO_3 (0.5 M)	4.0
				A.T.G. (0.04 M)	5.0

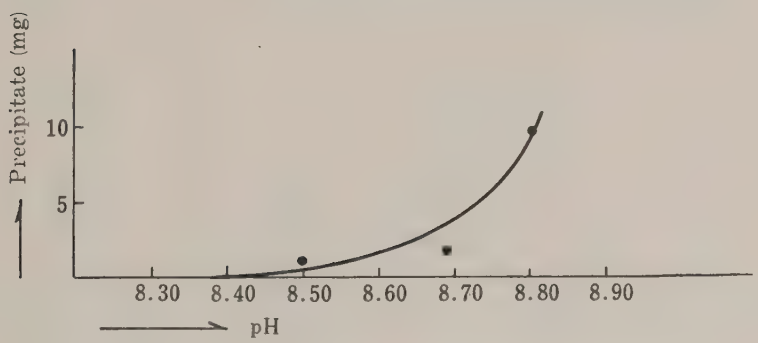

Fig. 2. Effect of pH upon the amount of the precipitate

As mentioned above, the precipitate can scarcely be observed in a solution having pH of less than 8.40, and the amount of the precipitate is gradually increased at pH value of 8.40~8.70, but it is suddenly increased in the neighbourhood of pH 8.70. From these results, it was concluded that one of the conditions under which a great deal of three component complex precipitate was formed, was the use of 0.5M boric acid at pH 8.70~8.80 and that the precipitate was easily soluble in acid medium.

(3) Effect of concentration and amount of various precipitants

i) In case of barium chloride

Such amount of 0.1M barium chloride as mentioned in Table 14 was added to a mixture of 4.0 ml of 4M ammonium chloride and 1.0 ml of 2N ammonium hydroxide, and then 0.5 ml of 0.3M boric acid, 4.0 l of 0.04M aravotrihydroxy glutaric acid and 3.0 l of ethyl alcohol were added. From this experiment, it was considered that when more than 6.0 ml of barium chloride were added, the amount of the precipitate might be reached to a constant weight. Namely, when 8.0 ml of barium chloride is added, the precipitation will be brought to completion. Further addition of barium chloride causes the existence of its excess and leads to the formation of two component precipitate. (Fig. 3)

Table 14. Effect of the amount of barium chloride upon the amount of the precipitate

$BaCl_2$ (0.1M)	ppt	Condition for precipation	
ml	mg		ml
1.0	2.8	NH_4Cl (4M)	4.0
2.0	14.0	NH_4OH (2N)	1.0
4.0	23.8	H_3BO_3 (0.3M)	0.5
8.0	26.9	A.T.G. (0.04M)	4.0
10.0	27.1	C_2H_5OH	3.0
		pH	8.65

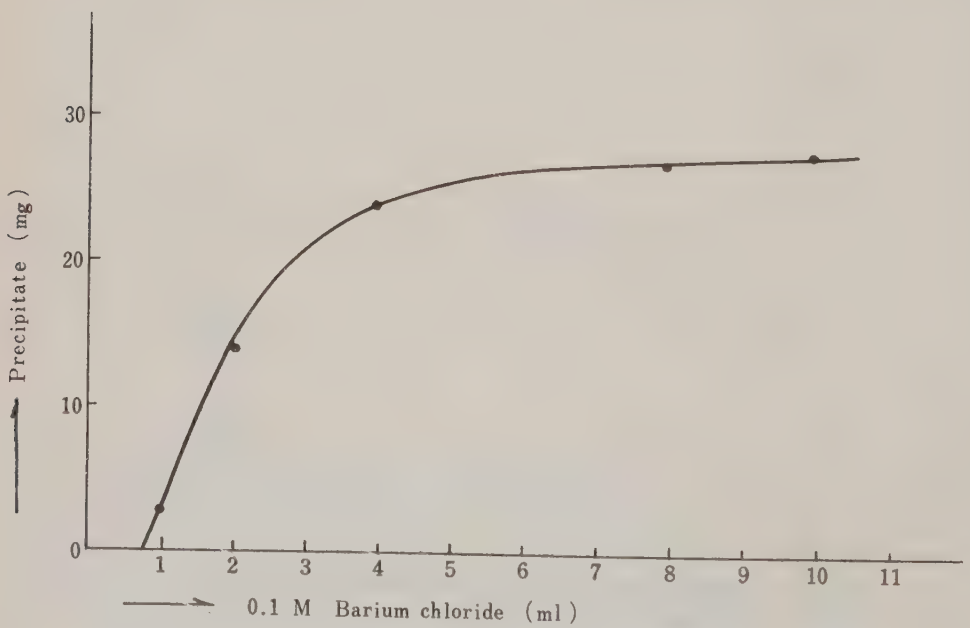

Fig. 3. Effect of the amount of barium chloride upon the amount of the precipitate

ii) In case of aravotrihydroxy glutaric acid

This experiment was carried out in the same procedure as that of previous one, by changing the concentration and the amount of aravotrihydroxy glutaric acid, keeping constant the amount of both barium chloride and boric acid.

As shown in Tables 15, 16, 17 and Fig. 4, the amount of the precipitate is increased in proportion to that of aravotrihydroxy glutaric acid.

Table 15. In case of 0.03M aravotrihydroxy glutaric acid

Ex. No.	A. T. G. (0.03M)	ppt	Ex. No.	A. T. G. (0.03M)	ppt	Condition for precipitation	
	ml	mg		ml	mg		ml
1	0.5		4	4.0	23.2	NH_4Cl (4M) NH_4OH (2N)	4.0 1.0
2	1.0	1.7	*5	4.0	13.4	$BaCl_2$ (0.1M)	6.0 8.0
3	2.0	9.7				H_3BO_3 (0.3M) C_2H_5OH	Ex. No. 5: 0.5 3.0

*5: Though the volume of barium chloride solution is 2.0 ml more than that of others, the amount of the precipitate is decreased owing to different order of adding the reagants.

Table 16. In case of 0.04M aravotrihydroxy glutaric acid

Ex. No.	A. T. G. (0.04M)	ppt	Condition for precipitation	
	ml	mg		ml
1	1.0	1.6	NH_4Cl (4M)	4.0
2	2.0	10.4	NH_4OH (2N)	1.0
3	4.0	23.8	$BaCl_2$ (0.1M)	4.0
4	8.0	39.6	H_3BO_3 (0.3M)	0.5
5	10.0	43.6	C_2H_5OH	3.0
**6	11.0	66.6		

**6: 8.0 ml of barium chloride were used. Perhaps, two component precipitate would be co-precipitated.

Table 17. In case of 0.05M aravotrihydroxy glutaric acid

Ex. No.	A. T. G. (0.05M)	ppt	Condition for precipitation	
	ml	mg		ml
7	0.5	1.0	NH_4Cl (4M)	4.0
8	1.0	6.3	NH_4OH (2N)	1.0
9	2.0	16.1	$BaCl_2$ (0.1M)	6.0
10	4.0	38.3	H_3BO_3 (0.3M)	0.5
			C_2H_5OH	3.0

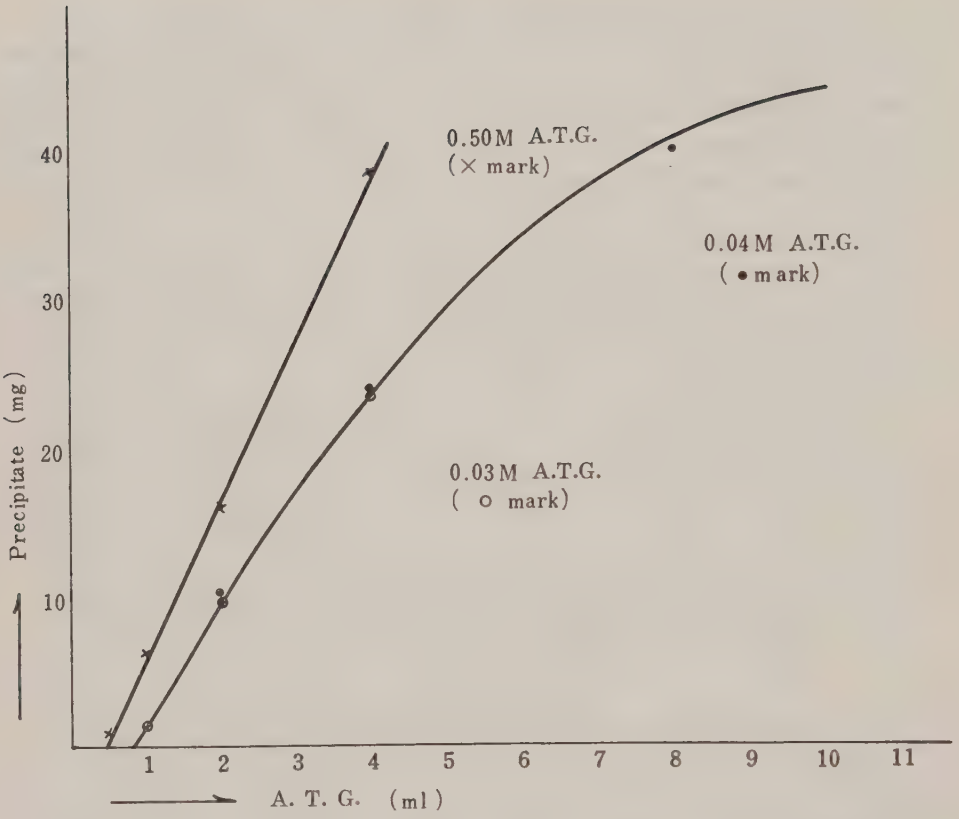

Fig. 4. Effect of the amount of aravotrihydroxy glutaric acid upon the amount of the precipitate

iii) In case of boric acid

The amount of the precipitate was studied by changing concentration and amount of boric acid against a definite amount of barium chloride and of every three concentrations (0.03M, 0.04M and 0.05M) of aravotrihydroxy glutaric acid.

The results are shown in Tables 18, 19 and 20.

As shown in Tables 18, 19, 20 and Fig. 5, the fact that in case of 0.03M aravotrihydroxy glutaric acid, the amount of the precipitate is greater than that in case of 0.04M aravotrihydroxy glutaric acid, will be perhaps due to the difference of added amount of barium chloride, and from Fig. 5, it was found that the amount of the precipitate was increased in proportion to that of boric acid up to an order of its 0.1 m mole solution, but at further addition of boric acid, it was almost independent of the addition. Perhaps, in this neighbourhood, precipitant would be consumed for the complete precipitation of three component complex.

Table 18. In case of 0.03M aravotrihydroxy glutaric acid

H_3BO_3	ppt	Condition for precipitation	
m mol	mg		ml
0.02	5.4	NH_4Cl (4 M)	4.0
0.05	14.7	NH_4OH (2 N)	1.0
0.10	18.3	$BaCl_2$ (0.1 M)	6.0
0.15	22.8	A.T.G. (0.03 M)	4.0
0.30	26.7	C_2H_5OH	3.0
0.50	28.9		

Table 19. In case of 0.05M aravotrihydroxy glutaric acid

H_3BO_3	ppt	Condition for precipitation	
m mol	mg		ml
0.02	19.8	NH_4Cl (4 M)	4.0
0.05	31.4	NH_4OH (2 N)	1.0
0.10	38.0	$BaCl_2$ (0.1 M)	8.0
0.15	42.6	A.T.G. (0.05 M)	4.0
0.30	46.0	C_2H_5OH	3.0
0.50	57.5		

Table 20. In case of 0.04M aravotrihydroxy glutaric acid

H_3BO_3	ppt	Condition for precipitation	
m mol	mg		ml
0.0055	1.0	NH_4Cl (4 M)	4.0
0.0105	3.4	NH_4OH (2 N)	1.0
0.03	10.3	$BaCl_2$ (0.1 M)	4.0
0.06	17.8	A.T.G. (0.04 M)	4.0
0.10	19.9	C_2H_5OH	3.0
0.15	23.8		
0.20	19.8		
0.30	24.5		
0.50	25.5		
1.00	26.9		
2.00	28.5		

(4) Effect of ethyl alcohol

i) Degree of the increased amount of the precipitate

The amount of the compound precipitated by the addition of ethyl alcohol was about twice as much as that in absence of alcohol and the effect of the different amount of ethyl alcohol upon the amount of the precipitate was not found.

ii) Effect of pH and the amount of ethyl alcohol

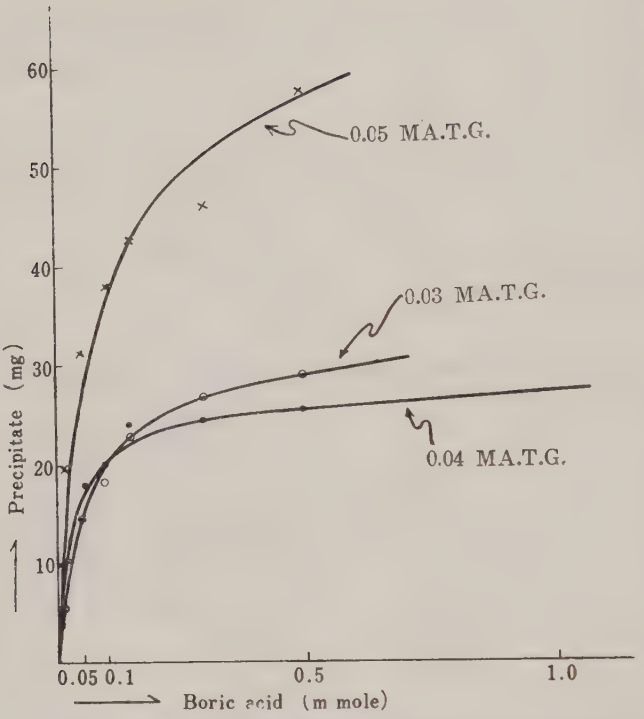

Fig. 5. Effect of the amount of boric acid upon the amount of the precipitate

Table 21. Degree of the increased amount of the precipitate

ppt in absence of ethyl alcohol	C_2H_5OH (25%)	Increase of ppt	Total ppt	Degree of increased amt. of ppt	Condition for precipitation	
mg	ml	mg	mg	—fold		ml
19.6	6.0	12.7	32.3	1.65	NH_4Cl(4M)	4.0
19.9	6.0	20.1	40.0	2.01	NH_4OH(2N)	1.0
20.0	6.0	16.2	36.2	1.81	$BaCl_2$(0.1M)	4.0
19.6	5.0	17.6	37.2	1.90	H_3BO_3(0.5M)	4.0
21.1	8.0	21.0	42.1	2.00	A.T.G.(0.05M)	5.0

Table 22. Effect of pH and the amount of ethyl alcohol upon the amount of the precipitate

Ex. No.	NH_4Cl(4M)	NH_4OH(2N)	C_2H_5OH(25%)	pH	ppt	
	ml	ml	ml		mg	%*
1	5.0	0.5	0	8.39	0.4	4.5
2	4.0	0.5	0	8.50	2.3	25.6
3	5.0	1.0	0	8.69	3.5	38.9
4	4.0	1.0	0	8.80	9.0	100.0
5	4.0	1.0	5.0	8.69	26.3	292.3

Ex. No.	C_2H_5OH(25%) First addition	Increase of ppt	Total ppt	Degree of increased amt. of ppt	ppt
	ml	mg	mg	—fold	%**
1′	5.0	8.0	8.4	21.0	38.8
2′	5.0	8.4	10.7	4.7	48.9
3′	5.0	7.0	10.5	3.0	48.0
4′	5.0	12.9	21.9	2.4	100.0
5′	5.0	2.0	28.3	1.1	

Ex. No.	C_2H_5OH(25%) Second addition	Increase of ppt	Total ppt	Degree of increased amt. of ppt	ppt	Condition for precipitation	
	ml	mg	mg	—fold	%***		ml
1″	6.0	15.1	23.5	58.8	71.4	$BaCl_2$(0.1M)	4.0
2″	6.0	13.9	24.6	10.7	74.8	H_3BO_3(0.5M)	4.0
3″	6.0	12.3	22.8	6.5	69.3	A.T.G.(0.04M)	5.0
4″	6.0	11.0	32.9	3.7	100.0		
5″	6.0	9.9	36.2	1.3			

*percentage based on Ex. No. 4
**percentage based on Ex. No. 4′
***percentage based on Ex. No. 4″

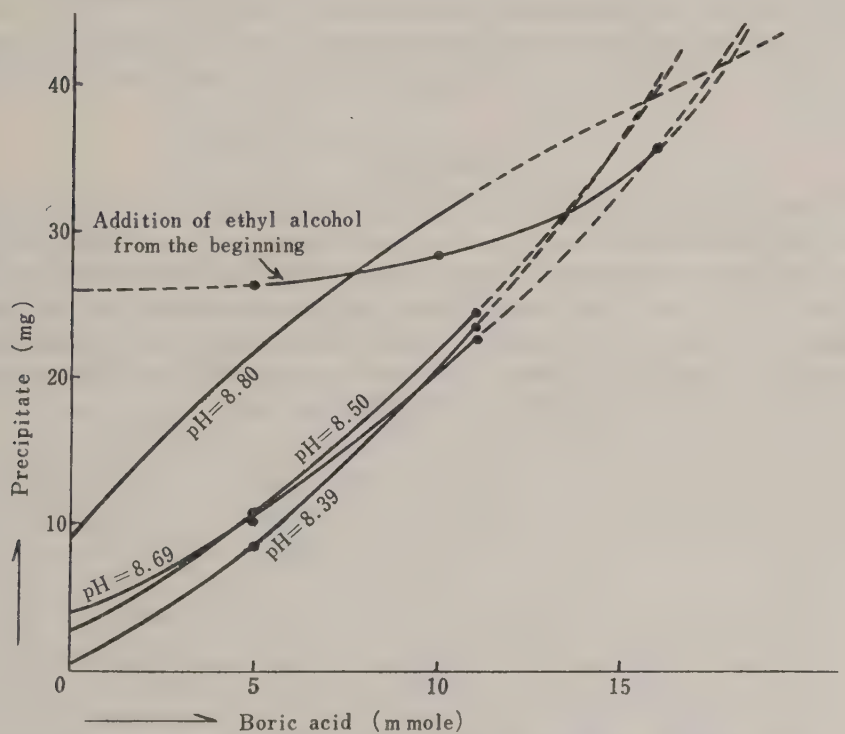

Fig. 6. Effect of pH and the amount of ethyl alcohol upon the amount of the precipitate

The above data are expressed in graph (Fig. 6). The amount of the precipitate nearly approaches to a constant, although the dotted line is an imaginary one, but there is, however, a risk of co-precipitation of two component precipitate, if a sufficient amount of ethyl alcohol to reach there is added.

Application of Barium boro manno saccharate to the Qualitative Analysis of Boric acid

It was convinced that the procedure mentioned in 1. at p. 100 is sufficiently applicable to the identification of boric acid in its solution.

In order to determine the limit of identification with respect to boric acid, the change of the amount of the precipitate was studied by adding various amounts of boric acid to a definit amount of the precipitant. Boric acid was found to be detectable in very diluted boric acid solution. The limit of identification of boric acid is 20 γ/ml as B.

Application of Barium boro aravotrihydroxy glutarate to the Qualitative Analysis of Boric acid

If a mixture of barium chloride and aravotrihydroxy glutaric acid is added to a diluted boric acid solution, it makes a bluish white turbidity, owing to the formation of three component precipitate, consisting of barium, aravotrihydroxy glutaric acid and boron. Therefore, this procedure may be applied to the qualitative analysis of boric acid.

Sensibility of boric acid was found to be 60 γ (4 γ/ml).

In this procedure, interference was caused by these ions, such as CO_3^{--}, SO_4^{--}, CrO_4^{--},$C_2O_4^{--}$, Ca^{++}, Mg^{++} etc. The above mentioned ions should be removed beforehand.

Conclusion

The conditions under which two component compound (e. g., barium borate, barium mannosaccharate and barium aravotrihydroxy glutarate) was not precipitated, were first determined, and then, beared those conditions in mind, the conditions of the formation of three component precipitate (e. g., barium boromanno saccharate and barium aravotrihydroxy glutarate) were studied. These three component complexes were easily precipitated, but the co-precipitation with the two component compound was occurred.

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STUDIES ON THE UTILIZATION OF THE SHALLOW-WATER DEPOSITS (Continued)

On the Lead Content of the Shallow-water Deposits

By

Masayoshi Ishibashi*, Shunzo Ueda** and Yoshikazu Yamamoto**

(*Faculty of Science, Kyoto University and **Faculty of Technology, Kanazawa University)

Introduction

In the previous paper[1], the authors reported on the zinc content of 139 shallow-water deposits collected at the sea-coasts of Japan proper and Korea and that of 23 deposits from various small islands around Japan proper. This time, the authors determined the lead content of the same samples, and furthermore analysed the deposits collected from different depths at Kasaoka Bay, Okayama Prefecture and Oki, Shimane Prefecture, in order to investigate the relation between the lead content of each deposit and the depth.

Experimental Procedure and Results

The determination of lead was carried out mainly by the dithizone method of E. B. Sandell[2].

On the Lead Content of the Shallow-water Deposits from the Sea-coasts of Japan proper and Korea

The analytical results of 139 deposits are shown in Table 1, in which the figures are given on the sea-salt-free and dry basis. It is seen from Table 1 that the lead content is considerably high in Sample 22 from Aichi Prefecture, Sample 81 from Mie, Sample 110 from Osaka, Sample 109 from Kyoto, Sample K 4 from Pyongan-namdo, Sample K 11 from Cholla, Samples K 16 and K 19 from Kyongsang, especially in Sample K 11, while it is exceedingly low in Sample 47 from Iwate, Sample 89 from Shizuoka, Sample 96 from Miyagi and Sample 99 from Ibaraki.

From the data in Table 1, we obtained the figures given in Table 2, which show that the average lead content of the Japanese samples is slightly lower than that of the Korean samples—sands as well as muds. The average lead content of sands is lower than that of muds, both in Japan and in Korea. Namely, it seems that lead has a tendency of preferring the hydrolyzates to the resistates in its distribution.

Next, comparing the data in Table 2 with the analyses of various sea-deposits by Tatsumoto[3], the average of all the Japanese samples is about the same as that of the 10 volcanic muds of the Pacific, 0.0011%, and considerably lower than the values for red clays* and the average of 44 blue muds etc. of the Japan Sea, 0.0049%. The average of all the Korean samples is higher than that of the volcanic muds but considerably lower than those of red clays and blue muds.

It seems that there is no relation, applicable to all the samples, between the lead content of the deposits and the amounts of other constituents. Though there are many exceptions, lead is high in fine muds which are rich in sulfur, and in sands which are high in SiO_2 and K_2O and low in Fe_2O_3 and MgO.

On the Relation between the Lead Content and the Geology

For the investigation of the relation between the lead content of the deposits and the geology of the land adjacent to the locations sampled, the authors analysed the same samples which were collected previousely from the various small islands having relatively simple geological structure and determined their copper and zinc contents[4].

The analytical results are shown in Table 3, in which the figures are given on the sea-salt-free and dry basis.

As, in the igneous rocks, lead is higher in acidic rocks than in basic ones[5], the authors expected that lead would be richer in the deposits from Hiroshima～Tashima, where acidic rocks predominate, than in those from Heigunshima and Kajishima, where basic rocks predominate. But the results show no conspicuous difference between the two groups of islands. In the deposits from Kasatoshima～Nushima, where the metamorphic rocks predominate, the lead content is about the same as that of the deposits from igneous rocks, being considerably higher in Takashima. As to the deposits of Shishishima～Himagashima, which consist mainly of sedimentary rocks, lead is higher in the deposits of Mesozoic formations, which are mostly composed of shale perhaps deposited in rather deep sea, while it is lower in Paleozoic formations and still lower in the Tertiary formations.

The results of Table 3 are summarized in Table 4.

On the Relation between the Lead Content and the Depth

In order to investigate the relation between the lead content of the deposits and the depth, the authors analysed the samples of various depths collected at Kasaoka Bay, Okayama Prefecture and Oki, Shimane Prefecture.

The analytical results are shown in Table 5.

As is clear from these data, there is no apparent relation between the lead content and the depth, though lead was found to be richest in the samples from the depth of about 40 m in both regions. It is necessary to study a much larger number of samples to see if there is any such relation.

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* Average of 22 red clays of the Pacific and that of 24 red clays of the Japan Sea are 0.006% and 0.0071%, respectively.

References

(1) M. Ishibashi, S. Ueda and Y. Yamamoto, Records of Oceanographic Works in Japan, (Special Number 3), p. 123 (1959).

(2) E. B. Sandell, "Colorimetric Determination of Traces of Metals," 2nd ed., p. 404 (1950) Interscience Publisher.

(3) M. Tatsumoto, J. Chem. Soc. Japan, 78, 42 (1957).

(4) M. Ishibashi, S. Ueda, Y. Yamamoto and F. Morii, Records of Oceanographic Works in Japan, (Special Number 2), p. 153 (1958); (Special Number 3), p. 123 (1959).

(5) K. Rankama, Th. G. Sahama, "Geochemistry," p. 729 (1950) Univ. Chicago Press.

Table 1. Lead content of the shallow-water deposits from Japan and Korea

Sample No.	Locality	Type of deposit	Pb content 10^{-4}%
1	Ataka-machi, Komatsu-shi, Ishikawa-ken	light brown sand	19
2	Mukōawagasaki, Uchinada-mura, Kahoku-gun, Ishikawa-ken	brown sand	8
3	Takahama, Takahama-machi, Hakui-gun, Ishikawa-ken	light brown sand	17
4	Ōkawa, Machino-machi, Fugeshi-gun, Ishikawa-ken	blackish sand	8
5	Fuzinami, Sannami-mura, Fugeshi-gun, Ishikawa-ken	blackish sand	8
6	Mattō, Nanao-shi, Ishikawa-ken	light grayish brown sand	12
7	Kubo, Kubo-mura, Himi-gun, Toyama-ken	light brown sand	15
8	Ebie, Ebie-mura, Imizu-gun, Toyama-ken	light grayish brown sand	15
9	Shimomuraki-machi, Uozu-machi, Shimoniikawa-gun, Toyama-ken	light yellowish sand	9
10	Ikuji-machi, Shimoniikawa-gun, Toyama-ken	small gravel	n.d.
11	Shimoarahama, Yachiho-mura, Nakakubiki-gun, Niigata-ken	grayish white sand	8
12	Kujiranami, Kashiwazaki-shi, Niigata-ken	blackish brown sand	14
13	Amaze, Izumozaki-machi, Santō-gun, Niigata-ken	brown sand	2
14	Kawakami, Ikarashihama, Uchino-machi, Nishikambara-gun, Niigata-ken	grayish white sand	8
15	Muramatsuhama, Matsuzuka-mura, Kitakambara-gun, Niigata-ken	grayish white sand	17

16	Aburato, Kamo-machi, Nishitagawa-gun, Yamagata-ken	grayish sand	11
17	Miyaumi, Nishiarase-mura, Akuumi-gun, Yamagata-ken	grayish white sand	7
18	Yoshigo, Tahara-machi, Atsumi-gun, Aichi-ken	grayish green fine mud	10
19	Ura, Tahara-machi, Atsumi-gun, Aichi-ken	grayish green fine mud	30
20	Namiirie, Oitsu-mura, Atsumi-gun, Aichi-ken	grayish green sandy mud	10
21	Nakane, Terazu-machi, Hazu-gun, Aichi-ken	grayish green sandy mud	20
22	Yoshihama, Takahama-machi, Hekikai-gun, Aichi-ken	grayish green fine mud	48
23	Ishikiri, Kamezaki, Handa-shi, Aichi-ken	grayish green sandy mud	n. d.
24	Nawa, Ueno-machi, Chita-gun, Aichi-ken	grayish green mud	20
25	Sankaku, Shimonoishiki-machi, Nakagawa-ku, Nagoya-shi, Aichi-ken	grayish green fine mud	20
26	Shingai-machi, Fukuyama-shi, Hiroshima-ken	grayish green fine mud	23
27	Minomi-machi, Numakuma-gun, Hiroshima-ken	grayish green fine mud	37
28	Yoshiwa-machi, Onomichi-shi, Hiroshima-ken	grayish green mud	12
29	Nouji, Saizaki-machi, Toyota-gun, Hiroshima-ken	yellowish white sand	18
30	Miyatoko, Tadanoumi-machi, Toyota-gun, Hiroshima-ken	light brown sand	16
31	Kitazaki, Takehara-machi, Kamo-gun, Hiroshima-ken	grayish green fine mud	28
32	Kirasaki, Shimono-mura, Kamo-gun, Hiroshima-ken	grayish green mud	7
33	Mitsu, Akitsu-machi, Kamo-gun, Hiroshima-ken	light grayish brown sand	8
34	Tsukimigahama, Itsukaichi, Itsukaichi-machi, Saeki-gun, Hiroshima-ken	light brown sand	16
35	Karasumori, Uchimichikawa, Michikawa-mura Yuri-gun, Akita-ken	grayish white sand	13
36	Shimodeto, Tennō-mura, Minamiakita-gun, Akita-ken	brown sand	8
37	Minamihirasawa, Funagawaminato-machi, Minamiakita-gun, Akita-ken	grayish white sand	9
38	Miyasawa, Katanishi-mura, Minamiakita-gun, Akita-ken	brown sand	8

39	Kohama, Kurosaki, Iwasaki-mura, Nishitsugaru-gun, Aomori-ken	grayish white sand	11
40	Isouchi, Rokumaibashi, Ushirogata-mura, Higashitsugaru-gun, Aomori-ken	blackish sand	5
41	Asadokoro, Kominato-machi, Higashitsugaru-gun, Aomori-ken	grayish sand	11
42	Uwano, Ōhata, Ōhata-machi, Shimokita-gun, Aomori-ken	brown sand	5
43	Tomari, Rokukasho-mura, Kamikita-gun, Aomori-ken	blackish brown sand	2
44	Hitokawame, Momoishi-machi, Kamikita-gun, Aomori-ken	blackish sand	4
45	Tamakawa, Noda-mura, Kunohe-gun, Iwate-ken	grayish white sand	7
46	Fujiwara, Miyako-shi, Iwate-ken	blackish sand	3
47	Tsugaruishi-mura, Shimohei-gun, Iwate-ken	grayish white sand	trace
48	Orikasa-mura, Shimohei-gun Iwate-ken	dark grayish sandy mud	5
49	Akasawa, Ōfunato-machi, Kesen-gun, Iwate-ken	blackish sand	2
50	Okiura, Higashikatakami, Katakami-machi, Wake-gun, Okayama-ken	dark grayish green fine mud	28
52	Awarigō, Nagahama-mura, Oku-gun, Okayama-ken	grayish green sandy mud	18
51	Nishitakasaki, Nadasaki-mura, Kojima-gun, Okayama-ken	grayish green fine mud	18
52	Nishitakasaki, Nadasaki-mura, Kojima-gun, Okayama-ken	grayish green fine mud	36
53	Ōsaki, Hachihama-machi, Kojima-gun, Okayama-ken	grayish green fine mud	18
54	Hachihama-machi, Kojima-gun, Okayama-ken	grayish green mud	26
55	Yorishima-machi, Asaguchi-gun, Okayama-ken	grayish green mud	14
56	Yōsuna, Kanaura-machi, Oda-gun, Okayama-ken	grayish green mud	31
57	Yanai-machi, Kuga-gun, Yamaguchi-ken	grayish green mud	14
58	Shinzaki, Higashitoyoi, Kudamatsu-shi, Yamaguchi-ken	grayish white sand	11
59	Ninomasu, Nakanoseki-machi, Hōfu-shi, Yamaguchi-ken	yellowish white sand	13
60	Kiwaura, Higashikiwa-mura, Yoshiki-gun, Yamaguchi-ken	yellowish white sand	7

61	Matsuoda, Shimonoseki-shi, Yamaguchi-ken	light brownish gray sand	8
62	Ōhibi, Senzaki-machi, Ōtsu-gun, Yamaguchi-ken	light brown sand	30
63	Uku, Nago-machi, Abu-gun, Yamaguchi-ken	grayish sand	6
64	Asari-mura, Naka-gun, Shimane-ken	yellowish white sand	6
65	Yasugi, Yasugi-machi, Nogi-gun, Shimane-ken	brown sand	18
66	Yoshizu, Sakitsu-mura, Saihaku-gun, Tottori-ken	grayish sand	8
67	Ōshimozu-mura, Saihaku-gun, Tottori-ken	yellowish white sand	6
68	Yodoe, Yodoe-machi, Saihaku-gun, Tottori-ken	grayish sand	19
69	Ajiro-mura, Iwami-gun, Tottori-ken	light brown sand	13
70	Ōkura-machi, Akashi-shi, Hyōgo-ken	yellowish white sand	27
71	Shinzaike, Aboshi-ku, Himeji-shi, Hyōgo-ken	grayish brown sand	24
72	Naba-machi, Aioi-shi, Hyōgo-ken	grayish green mud	33
73	Naba-machi, Aioi-shi, Hyōgo-ken	grayish green mud	37
74	Miwasaki-machi, Shingū-shi, Wakayama-ken	blackish gray sand	4
75	Hosono, Katata, Nishitonda-mura, Nishimuro-gun, Wakayama-ken	light brown sandy mud	6
76	Kitahara, Shinjō-mura, Nishimuro-gun, Wakayama-ken	light brown sandy mud	9
77	Minabe-machi, Hidaka-gun, Wakayama-ken	brown sand	7
78	Enokoma, Yura-machi, Hidaka-gun, Wakayama-ken	light brown sand	11
79	Ōyodo, Ōyodo-machi, Take-gun, Mie-ken	light grayish brown sand	14
80	Funakoshi-mura, Shima-gun, Mie-ken	grayish white sandy mud	37
81	Nagashima-machi, Kitamuro-gun, Mie-ken	blackish brown sand	42
83	Suna, Hasunuma-mura, Sanbu-gun, Chiba-ken	light brown sand	11
84	Hama-machi, Anesaki, Anesaki-machi, Ichihara-gun, Chiba-ken	blackish gray sand	4
85	Hon-machi, Funabashi-shi, Chiba-ken	light blackish brown sand	14

86	Kanazawa-machi, Isogo-ku, Yokohama-shi, Kanagawa-ken	grayish sand	24
87	Ōiso, Ōiso-machi, Naka-gun, Kanagawa-ken	blackish sand	3
88	Sakawa, Sakawa-machi, Ashigarashimo-gun, Kanagawa-ken	blackish sand	2
89	Usami-mura, Tagata-gun, Shizuoka-ken	blackish brown sand	trace
90	Tago, Tagonoura-mura, Fuji-gun, Shizuoka-ken	blackish gray sand	16
91	Chihama, Chihama-mura, Ogasa-gun, Shizuoka-ken	light blackish gray sand	6
92	Hamana, Arai-machi, Hamana-gun, Shizuoka-ken	light blackish gray sand	2
111	Namiita, Shishiori-mura, Motoyoshi-gun, Miyagi-ken	grayish sandy mud	8
93	Namiita, Shishiori-mura, Motoyoshi-gun, Miyagi-ken	grayish mud	11
94	Shizukawa-machi, Motoyoshi-gun, Miyagi-ken	grayish white sand	4
95	Ōmagari, Yamoto-machi, Monou-gun, Miyagi-ken	light brown sand	2
96	Nakahama, Sakamoto, Sakamoto-mura, Watari-gun, Miyagi-ken	light yellowish gray sand	1
97	Shin-machi, Ukedo, Ukedo-mura, Futaba-gun, Fukushima-ken	light brownish gray sand	3
98	Naka-machi, Yotsukura-machi, Iwaki-gun, Fukushima-ken	light yellowish gray sand	7
99	Kawajiri, Toyoura-machi, Taga-gun, Ibaraki-ken	light brownish gray sand	1
100	Akashi, Namino-mura, Kashima-gun, Ibaraki-ken	light brownish gray sand	11
101	Yoshimi, Tajiri-mura, Sennan-gun, Ōsaka-fu	yellowish brown sand	7
110	Kamiya-machi, Kishiwada-shi, Ōsaka-fu	yellowish brown sand	47
102	Shiomi-machi, Izumiōtsu-shi, Ōsaka-fu	light yellowish brown sand	19
103	Hamazume-mura, Takeno-gun, Kyōto-fu	light brown sand	16
104	Iwagahana, Yōrō-mura, Yoza-gun, Kyōto-fu	light brown sand	4
109	Shimasaki, Miyazu-machi, Yoza-gun, Kyōto-fu	light brown sand	48
105	Higashikanzaki, Kanzaki-mura, Kasa-gun, Kyōto-fu	light brownish gray sand	2

106	Wakamiya, Takahama-machi, Ōi-gun, Fukui-ken	greenish black sand	8
107	Shirahige, Obama-machi, Onyū-gun, Fukui-ken	grayish brown sand	9
108	Ishishinbo, Natsume-mura, Sakai-gun, Fukui-ken	brown sand	11
K 1	Puna, Yongchon-kun, Pyonganpukto	dark brown mud	n. d.
K 2	Osong-tong, Taesan-myon, Sonchon-kun, Pyongan-pukto	dark brown mud	17
K 3	Hampal-ri, Hanchon-myon, Pyongwon-kun, Pyongan-namdo	dark brown mud	20
K 4	Okyangki-ri, Chinnampopu, Pyongan-namdo	dark brown mud	60
K 5	Yonghoto-ri, Tongnam-myon, Ongjin-kun, Hwaghae-do	dark brown mud	15
K 6	Chinjong-ri, Sonwon-myon, Kanghwa-kun, Kyonggi-do	dark brown mud	13
K 7	Tongjoung-ri, Sokumun-myon, Tangjin-kun, Chungchong-namdo	dark brown mud	10
K 8	Sopinchon, Kunsanpu, Cholla-pukto	dark brown mud	21
K 9	Namchang-ri, Pukpyong-myon, Haenam-kun, Cholla-namdo	dark brown mud	28
K 10	Mayang-ri, Taeku-myon, Kangjin-kun, Cholla-namdo	dark brown mud	11
K 11	Haean, Kuhangshine, Yosu-ub, Yosu-kun, Cholla-namdo	dark brown mud	89
K 12_1	Royang-ri, Kumnan-myon, Hadong-kun, Kyongsang-namdo	dark brown sandy mud	12
K 12_2	Royang-ri, Kumnan-myon, Hadong-kun, Kyongsang-namdo	dark brown mud	23
K 13	Sonjin-ri, Yongkyoun-myon, Sachon-kun, Kyongsang-namdo	dark brown sandy mud	11
K 14	Tupu-ri, Samsan-myon, Kosong-kun, Kyongsang-namdo	dark brown mud	24
K 15	Shinjon-ri, Sanyang-myon, Tongyong-kun, Kyongsang-namdo	dark brown sandy mud	21
K 16	Kyonghwa-tong, Chinhae-ub, Changwon-kun, Kyongsang-namdo	brown mud	46
K 17	Chedok-ri, Ungchon-myon, Changwon-kun, Kyongsang-namdo	dark brown mud	15
K 18	Bangou-ri, Tong-myon, Ulsan-kun, Kyongsang-namdo	yellow clay	5
K 19_1	Pohang-tong, Pohang-ub, Yongil-kun, Kyongsang-pukto	dark brown mud	49

K 19_2	Pohang-tong, Pohang-ub, Yongil-kun, Kyongsang-pukto	light yellowish brown sand	11
K 20	Imwon-ri, Wondok-myon, Samchok-kun, Kangwon-do	light yellowish brown sand	14
K 21	Chumun-ri, Chumunjin-myon, Kangnung-kun, Kangwon-do	yellowish white sand	19
K 22	Haean-tong, Wonsanpu, Hamgyong-namdo	light yellowish brown sand	4
K 23	Hengchon, Songjin-ub, Songjin-kun, Hamgyong-pukto	light brown sand	5
K 24	Songshin-tong, Ouyang-myon, Kyongsong-kun, Hamgyong-pukto	light brown sand	18
K 25	Tokyoun-tong, Ochon-myon, Kyongsong-kun, Hamgyong-pukto	grayish white sand	28
K 26_1	Bipa-tong, Songpyong-tong, Unggi-ub, Kyonghung-kun, Hamgyong-pukto	grayish white sand	15
K 26_2	Ungsang-tong, Unggi-ub, Kyonghung-kun, Hamgyong-pukto	light yellowish brown sand	14
K 26_3	Unggi-tong, Unggi-ub, Kyonghung-kun, Hamgyong-pukto	grayish white sand	10
K 27	Sosura-tong, Roso-myon, Kyonghung-kun, Hamgyoung-pukto	grayish white sand	9

Table 2. Summary of Table 1.

Number of samples		Pb content (10^{-4}%)	
		Range	Average
Total samples from Japan	109	trace ~ 48	14
Sands	80	trace ~ 48	11
Muds	29	5 ~ 48	21
Total samples from Korea	30	4 ~ 89	21
Sands	11	4 ~ 28	13
Muds	19	5 ~ 89	26

Table 3. Lead content of the shallow-water

Locality	Geology**	Type of deposits
Hiroshima, Kagawa-ken	Granites	grayish white sand
Nakashima, Ehime-ken	Granites	light brown sand
Ogishima, Kagawa-ken	Granites (Sanukite)	light brown sand
Momoshima, Hiroshima-ken	Granites	light brown sand
Yokoshima, Hiroshima-ken	Granites	light brown sand
Okinoshima, Kōchi-ken	Granites	light brown sand
Kogoshima, Ehime-ken	Granites	brown sand
Kōnoshima, Okayama-ken	Quartz-porphyry	light brown
Tashima, Hiroshima-ken	Quartz-porphyry (Granites, Ryōke metamorphics)	greenish sandy mud
Heigushima, Yamaguchi-ken	Pyroxene-andesite	grayish brown sand
Kajishima, Ehime-ken	Norite	light blackish gray sand
Kasatoshima, Yamaguchi-ken	Ryōke metamorphics (Granites)	grayish brown sandy mud
Ōtsushima, Yamaguchi-ken	Sangun metamorphics (Granites)	blackish green sand
Takashima, Ōita-ken	Sanbagawa metamorphics	grayish blue sand
Nushima, Hyōgo-ken	Greenshist, Black phyllite	grayish white sand
Shishishima, Kagawa-ken	Upper Paleozoic formations	light brown sand
Mutsukishima, Ehime-ken	Upper Paleozoic formations (Granites)	yellowish brown sand
Ōnyūshima, Ōita-ken	Mesozoic formations	brown sand
Shimoniizu-mura, Ōita-ken	Mesozoic formations	brown sand
Sugari, Owashi-shi, Mie-ken	Mesozoic formations	blackish gray sand
Tobishima, Yamagata-ken	Tertiary formations	blackish gray sand
Higashitonda-mura, Wakayama-ken	Tertiary formations	light blackish gray sand
Himagashima, Aichi-ken	Tertiary formations	light grayish brown sand

* Three capes are also included.

** Only the predominant rocks and formations are shown. The parentheses location sampled.

deposits collected from small islands*

Composits of	Pb content 10^{-4}%	SiO_2%	Fe_2O_3%	Al_2O_3%	MnO%	CaO%	MgO%	CO_2%
5 deposits	25	82.92	0.56	9.23	trace	0.74	0.33	—
5 „	19	79.28	1.26	11.01	0.01	1.09	0.34	—
5 „	17	77.49	1.97	12.16	0.03	2.23	0.24	—
4 „	14	75.81	2.34	12.21	0.04	1.69	0.40	—
5 „	20	76.21	2.49	14.77	0.03	1.32	0.25	—
5 „	22	73.96	3.08	10.40	0.04	3.76	0.46	2.33
3 „	8	70.62	4.28	12.98	0.11	2.85	1.14	1.66
5 „	24	79.24	1.56	9.74	0.02	2.57	0.56	1.28
5 „	15	75.87	2.02	11.52	0.03	0.90	0.49	—
2 „	26	71.20	2.98	13.49	0.04	2.92	1.87	—
5 „	16	52.64	8.25	20.06	0.18	9.69	4.58	0.52
4 „	17	79.36	3.05	6.82	0.11	2.82	1.12	1.58
2 „	16	47.48	6.14	12.31	0.12	15.95	2.74	8.28
5 „	35	70.02	2.87	9.51	0.06	7.05	1.86	4.01
5 „	10	74.26	2.16	7.07	0.06	5.62	0.74	3.86
5 „	15	87.54	1.00	5.77	0.04	1.19	0.21	—
2 „	16	79.25	1.02	10.05	0.01	2.13	0.52	—
4 „	79	76.42	2.99	10.95	0.03	1.80	0.26	0.50
5 „	31	70.67	5.21	13.37	0.08	0.76	1.10	—
4 „	15	72.20	3.38	11.27	0.04	3.45	0.65	1.20
4 „	7	57.69	3.69	14.82	0.05	8.56	2.20	5.14
4 „	11	56.25	2.76	7.15	0.01	15.27	1.25	11.28
5 „	14	77.54	1.79	8.77	0.01	3.83	0.51	2.18

are for the rocks which distribute in the land areas relatively far from the

Table 4. Lead content and the geology (summary of Table 3)

Geology	Number of samples	Pb content (10^{-4}%)	
		Range	Average
Igneous rocks			
Acidic rocks	9	14 ~ 25	18
Basic rocks	2	16 ~ 26	21
Metamorphic rocks			
Gneisses	1	—	17
Crystalline schists	3	10 ~ 35	20
Sedimentary rocks			
Upper Paleozoic formations	2	15 ~ 16	16
Mesozoic formations	3	15 ~ 79	42
Tertiary formations	3	7 ~ 14	11

Table 5. Lead content of the deposits of various depths

Kasaoka Bay, Okayama Prefecture

Depth (m)	Number of samples	Type of deposits	Pb content (10^{-4}%)
1.7 ~ 3.4	3	mud	41
6.7	2	mud	34
9.2 ~ 13.1	2	mud	33
15.8 ~ 17.3	3	mud	28
39	1	mud	60

Oki, Shimane Prefecture

Depth (m)	Number of samples	Type of deposits	Pb content (10^{-4}%)
9.3	1	mud	18
11.8	1	mud	13
23	1	mud	15
27	1	mud	16
36	1	mud	33
41	1	mud	49

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DISTRIBUTION OF BORON IN URADO BAY

Especially about the Variations of Boron Content Accompanied by the Dilution of the Sea Water

By

Hiroshi Yamamoto and Yoshihiko Imai

(Chemistry Institute, Faculty of Education, Kochi University)

Preface

It is known that boron in the sea water plays an important part as ion which is related to pH of the sea water, because of its bringing change to the buffer action as well as carbonate according to its quantity.[1)]

And it is also reported[2)] that boron can be used as an indicator of the water mass analysis on account of its interesting distribution.

It is considered that the water of inlets when compared with the water of the open sea is much more affected by various factors such as dilution by land water, increase of the marine living things, effect of sediment, suspension, impurities, etc. Consequently it can be expected that the boron content in the water of inlets will show different distribution from that of the water of the open sea, and it is of great interest to know if each inlet has its own peculiarity.

The writers, as a part of their research of oceanographical chemistry of inlets, have already studied by the method of measuring chlorinity ratio of calcium and magnesium how the chemical composition of the sea water changes when diluted by the land water. This time with the application of this idea, the boron in the sea water of Urado Bay has been analyzed. And on the data of this chemical analysis, it is clearly observed how the composition of the sea water changes when diluted by land water.

Experiment

Sample

The sample is the sea water taken on June 10 and Oct. 28, 1958 at the stations shown Fig. 1. It was put to the analysis after filtrated.

Quantitative Analysis Method

Kawaguchi Method on natural water,[3)] being examined, was applied to the sample and found appropriate to our present analysis. Therefore, by this method 2 cc sample water was put into a colouring tube and added 10 cc conc. (H_2SO_4) sulphuric acid and 10cc carmine solution (conc. sulphuric acid solution

containing 0.05% carmine). After an hour its colorimetry was measured by the spectrophotometer in the 910 mμ wave length.

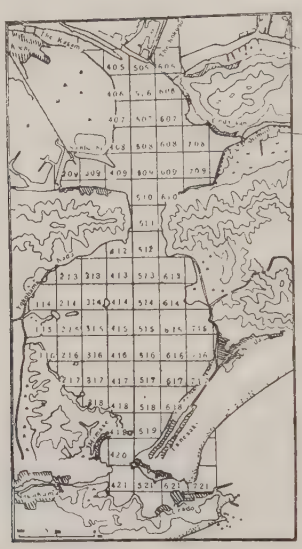

Fig. 1. The marshal grid
Observational stations are at center of square.

Results and Discussion

The results of the experiment are shown in Figs. 1 and 2. The boron content in the sea water of Urado Bay is usually 1.2 to 4.55 mg/1; with small amount in the surface layer and the gradual increase toward the bottom layer. It sometimes shows low data, however, when the sea water is diluted by land water after the rise of a river due to the rainfall.

The picture of the vertical cross-section according to the data on each station crossing the bay, indicates (as shown in Fig. 2) that the distribution of boron is generally similar to that of chlorine. The result of the investigation shows that the boron ratios as well as chlorinity are high on the side of St. 115 and low on that of St. 715. This is due to the fact that comparatively salty water strongly influenced by open sea flows a little left side of the center. This movement of the sea water is much affected by geographical features.

The salty sea water like this contains much boron. In order to see how boron is diluted when open sea water diluted and becomes of different salinity, the boron content corresponding to chlorinity is plotted as shown in Fig. 3. The data taken from much material of inlet water indicate that they distribute on one straight line. Regardless of the density of the sea water, much change can not be observed in the ratio of boron to chlorinity. However, the boron in the materials taken from Sts. 215, 315 etc., shows a little higher characteristic

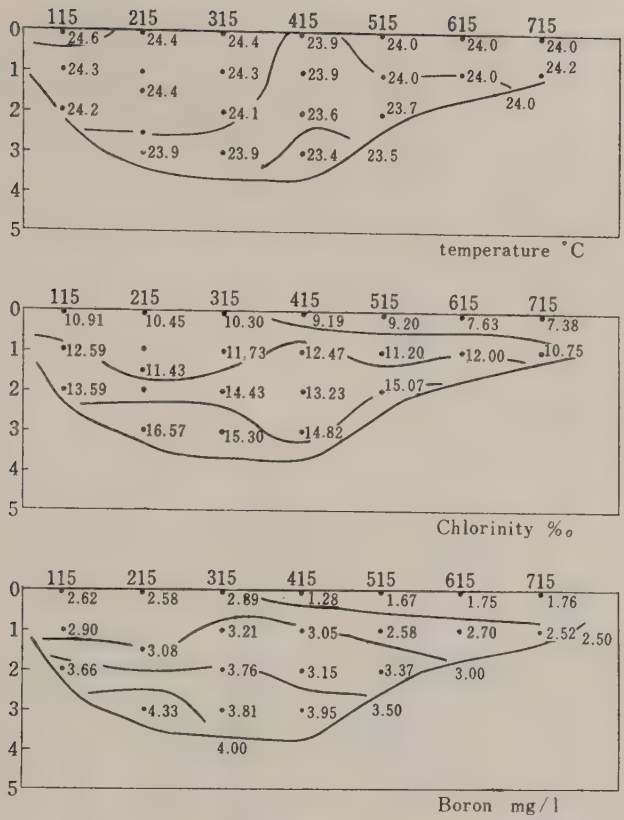

Fig. 2. Vertical distribution of temperature, chlorinity and boron in St. 115~715 in normal conditions of low water (Jul. 10, 1958)

data than that from other stations (shown in dotted line). The reason for this high data in a station like this is not clear, but it is worth noticing.

Due to the fact that the quantitative relation between boron and chlorinity is thus very close, chlorinity ratio of boron does not change much when the sea water has the same amount of chlorinity content. Chlorinity ratio of boron in the data of the material covering the whole Urado Bay is $22.5 \sim 24.4 \times 10^{-5}$.

Profound thanks are extended to Prof. M. Ishibashi of Kyoto University for good suggestion about this investigation.

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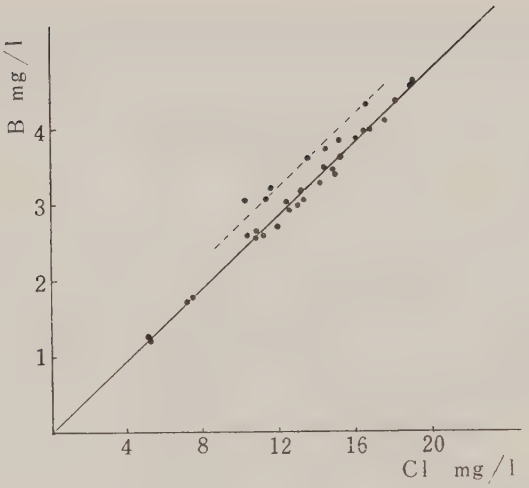

Fig. 3. Relation between chlorinity and boron content in sea water

Table 1. (collected on Jul. 10, 1958)

St. No.	depth (m)	temp. (°C)	Cl (‰)	B (mg/l)	B/Cl × 10^{-5}
115	0	24.6	10.91	2.62	24.0
	1	24.3	12.59	2.91	23.5
	2	24.2	13.59	3.66	26.5
215	0	24.4	10.45	2.58	24.7
	1.5	24.4	11.43	3.08	29.5
	3	23.9	16.57	4.33	26.2
315	0	24.4	10.30	2.89	28.2
	1	24.3	11.73	3.21	27.4
	2	24.1	14.43	3.76	26.1
	3	24.1	15.30	3.81	24.9
415	0	23.9	5.19	1.28	24.7
	1	23.9	12.41	3.05	24.6
	2	23.6	13.23	3.15	23.8
	3	23.4	12.82	2.98	23.2
515	0	24.0	7.20	1.67	23.3
	1	24.0	11.20	2.58	22.8
	2	23.7	15.07	3.37	22.4
615	0	24.0	7.63	1.75	23.0
	1	24.0	12.00	2.70	22.5
715	0	24.0	7.38	1.76	23.9
	1	24.2	10.75	2.52	23.4

Table 2. (collected on Oct. 28, 1958)

St. No.	depth (m)	temp. (°C)	Cl (‰)	B (mg/l)	$B/Cl \times 10^{-5}$
405	0	15.0	5.35	1.23	23.0
	1.5	20.4	14.96	3.44	23.0
708	0	18.8	14.50	3.49	24.1
	1	21.3	16.18	3.87	23.9
510	0	18.5	12.41	3.02	22.5
	1	20.6	15.45	3.63	23.5
	2	22.1	16.82	3.97	23.6
513	0	22.1	15.37	3.60	23.4
	1	22.7	16.55	3.94	23.8
	2	22.7	18.30	4.46	24.4
	4	22.8	18.91	4.52	23.8
	6	22.9	19.00	4.56	24.0
515	0	17.2	10.72	2.50	23.3
	1	20.4	15.90	3.75	23.6
	2	21.5	14.85	3.46	23.3
	3	22.3	18.15	4.35	24.0
518	0	18.6	14.20	3.28	23.1
	1	19.2	15.00	3.45	23.0
	2	21.3	16.88	4.08	24.2
	4	21.6	17.60	4.06	23.1
	8	22.2	18.20	4.36	24.0
721	0	19.6	19.42	4.56	23.7

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STUDIES ON INORGANIC CHEMICAL CONSTITUENTS IN SEA FISHES

The Chemical Elements, and the Relative Quantities of Calcium and Phosphorus in *Katsuwonus pelamis* (Part 4)

By

Noboru Imanishi

(Chemical Laboratory, Faculty of Literature and Science, Kochi University)

Calcium and phosphorus are important elements for all beings.

The author presented a report[1] on the relative quantities of calcium and phosphorus in deep-sea fishes.

This paper presents the distribution and the relative quantities of these two elements in *Katsuwonus pelamis*, one of circulating fishes.

Samples and their Treatments

Katsuwonus pelamis were obtained from a market in Kochi City, Japan. (May, 1958)

Fishes' bodies were well washed to clean off sea water, sands and others which contaminated them. Then they were divided into their respective parts as head, bone, flesh or inner organs, and dried by the heat of burning charcoal or infra-red lamp. Dried parts were heated at first to char in evaporating dishes, and then transferred into an electric muffle furnace to burn to ashes at the temperature of 500°~550°C.

Chemical Elements Contained in Ashes

Ashes from the fish were mainly examined by the spectrographic analysis. The chemical elements found by this method are as follows. (Table 1)

Nonmetallic elements, such as Cl, $S(SO_4)$ and $C(CO_3)$, were detected by the paper chromatography or the other usual chemical methods.

On the Quantities of Calcium and Phosphorus

Methods of Analysis

The outline of the analysis is shown in Table 2.

The Determination of Calcium

The ashes were first dissolved in a little quantity of concentrated nitric acid.

Table 1. Results of spectrographic analysis of the ash of *Katsuwonus pelamis*

Parts of Fish	Cu	Pb	Sn	Fe	Al	Mn	Zn	Ca	Mg	Na	K	Si	P
Bone	2	1·	2·	1·	1.	1·	2·	5	4	5	5	2·	3
Head	2·	2	2·	1·	tr.	1	2·	5	4·	5	5	1	3
Gills	2·	2	2·	2	1·	1·	3	5	4·	5	5	2	3
Flesh (white)	1·	2·	1	2	2·	1	2	5	5	5	5	3·	3
Flesh (red)	2·	3	2	2·	4	—	2·	5	4·	5	5	4	4
Heart	3	2	2	4	3	tr.	2·	5	5	5	5	3·	3
Liver	1·	1	1·	2	2	1	2	4·	4	5	5	2·	3·
Pyloric Appendage	2	2·	1·	2	3	1	3	5	5	5	5	3	3·
Stomach	2	2·	1	2	2	1	5	5	5	5	5	3	3·

Conditions: Pulsating Current Arc; Voltage AC 220 V; Curr. 6 Amp; Breadth of Slit 0.005 mm; Height of Slit 3 mm; Time of Exposure 30 sec; Distance of Electrode 2 mm; Apparatus Shimazu Spectrograph QF–60 Type.

Figures indicate approximately the relative amount of elements, and these having a point on the right shoulder indicate larger quantity than otherwise.

Centrifuged out any insoluble residue, and the pH value of the solution is regulated to 1.5～2.0. The solution thus obtained is introduced to the column of acid formed cation exchange resin, Amberlite IR–120, and then anions such as phosphate, chloride and sulphate ions are washed out by distilled water.

The calcium in the column is eluted by the solution of 1.0 F ammonium acetate. The effluent contains all calcium ions and some other cations, such as ions of alkali metals, magnesium and bivalent transition elements, copper, zinc, etc.. Calcium is titrated by the 0.01M EDTA at pH 12, under masking transition elements by potassium cyanide solution. Magnesium setting down in precipitate and alkali elements in solution have no effect on the titration.

The Determination of Phosphorus

Phosphate in the solution obtained as shown in Table 2 is determined by the ISHIBASHI'S method[2]. Namely, phosphate ion is precipitated by ammonium molybdate and other specified reagents, and thus obtained precipitate of ammonium phosphomolybdate is dissolved in known excess of sodium hydroxide solution and then titrated back.

Results and Discussions

The distribution of calcium and phosphorus and the order in quantity of them in *Katsuwonus pelamis* are shown in Table 3.

Table 2. Scheme of analysis

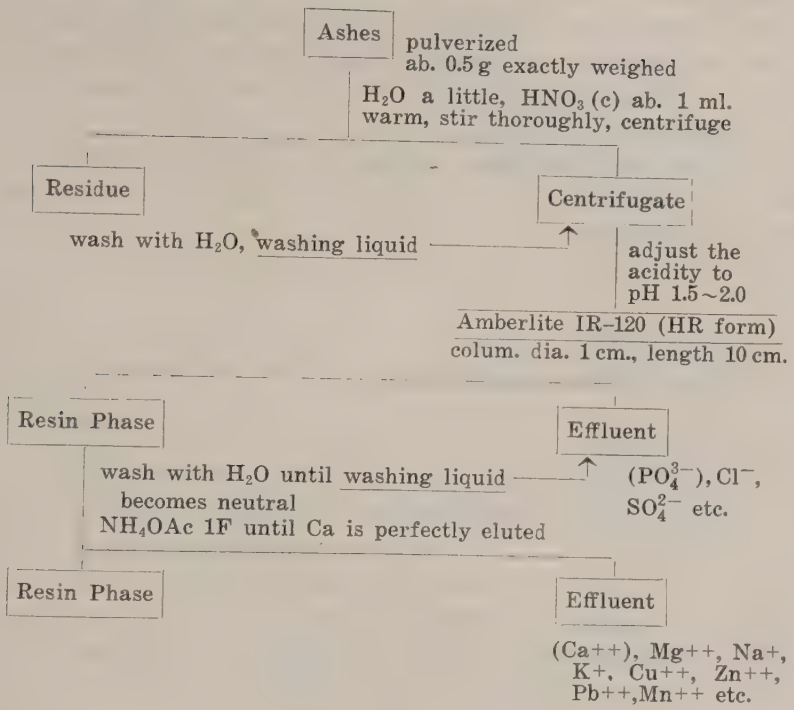

Ashes
pulverized
ab. 0.5 g exactly weighed
H_2O a little, HNO_3 (c) ab. 1 ml.
warm, stir thoroughly, centrifuge
Residue
Centrifugate
wash with H_2O, washing liquid
adjust the acidity to pH 1.5~2.0
Amberlite IR-120 (HR form)
colum. dia. 1 cm., length 10 cm.
Resin Phase
Effluent
wash with H_2O until washing liquid becomes neutral
NH_4OAc 1F until Ca is perfectly eluted
(PO_4^{3-}), Cl^-, SO_4^{2-} etc.
Resin Phase
Effluent
(Ca++), Mg++, Na+, K+, Cu++, Zn++, Pb++, Mn++ etc.

Table 3. Orders of the quantities of calcium and phosphorus

Order	Ca		P	
	Parts	gram atom $\times 10^3$	Parts	gram atom $\times 10^3$
1	Bone	9.40	Flesh (white)	6.47
2	Head	8.60	Gills	6.17
3	Gills	8.15	Flesh (red)	6.10
4	Stomach	0.97	Bone	5.75
5	Flesh (red)	0.90	Liver	5.75
6	Pyloric appendage	0.60	Pyloric appendage	5.26
7	Heart	0.25	Stomach	5.23
8	Flesh (white)	0.24	Head	5.19
9	Liver	0.19	Heart	4.50

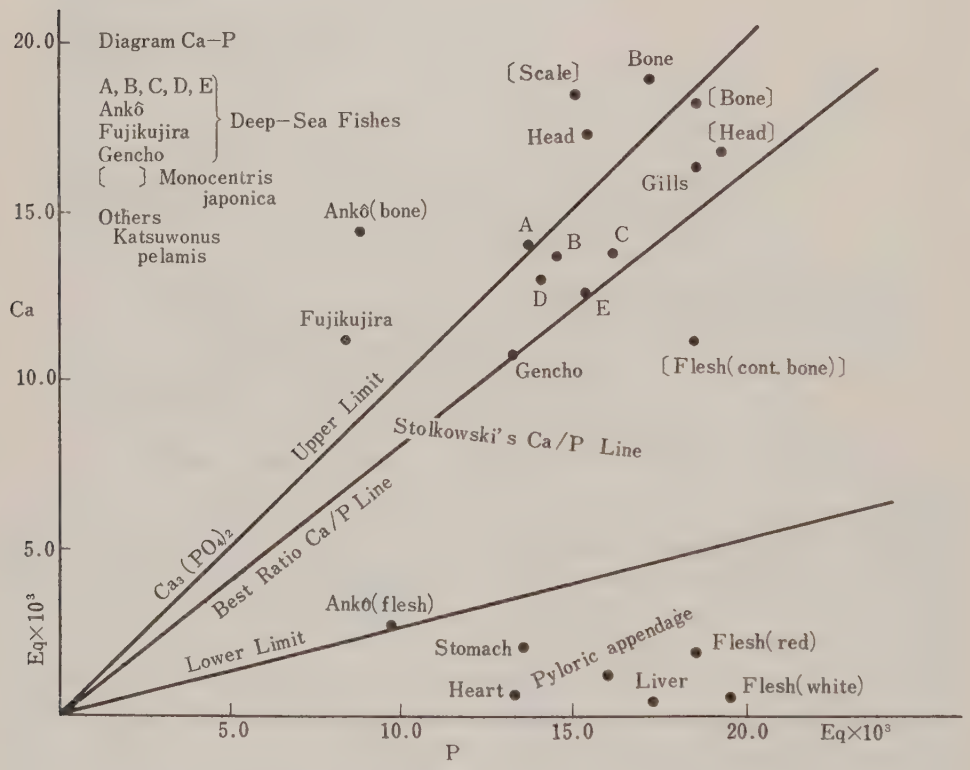
(per 1 g of ash)

Figures indicate the quantities of calcium and phosphorus in gram atom number per 1 g of ashes.

Calcium is rich in bone, head and gills and poor in flesh and inner organs, and in the latter parts it amounts to 1/10～1/50 of the quantity in the former.

On the contrary, the distribution of phosphorus is generally uniform in the body. From this point it will be found that the phosphorus is essential element to all parts of beings.

The quantitative relations between calcium and phosphorus in parts of *Katsuwonus pelamis*, such as head, gills, bone, flesh and inner organs are shown in the following figure.



The longitudinal axis indicates the gram equivalent of calcium, and the lateral axis indicates that of phosphorus.

The term of gram equivalent used here is the one derived from the quantitative relation between calcium and phosphorus in the compound of $Ca_3(PO_4)_2$. The equivalent of calcium is the half of its atomic weight, and that of phosphorus is one third of its atomic weight.

The diagonal, equivalent line indicates the quantitative ratio of calcium to phosphorus in the compound of $Ca_3(PO_4)_2$.

The ratios of bone, head, gills and scale are situated in the vicinity of this line.

The deep-sea fishes are also dotted about here. Namely it indicates that the quantitative ratio of calcium to phosphorus in these parts of *Katsuwonus pelamis* and in deep-sea fishes as a whole is nearly the same as that in the compound of $Ca_3(PO_4)_2$.

The ratios of flesh and inner organs are situated together at the right down part of the diagram. These parts are, that is to say, rich with phosphorus and poor with calcium.

For reference, the parts of *Monocentris japonica* are also shown in this diagram. Stolkowski emphasizes the important roles of calcium in the body of beings in his book "Calcium et la Vie".[3)]

He indicates also how is the best proportion of calcium and phosphorus that must be contained in the nutrition for human beings, especially children and pregnant women.

The line indicating the best quantitative ratio of calcium to phosphorus as he calls, passes through the part of deep-sea fishes. From this point of view, it will be found that we must eat small fishes as a whole.

By taking flesh as nutrition, we may obtain enough phosphorus, though we can not get enough calcium to keep good health.

The author wishes to thank Dr. M. Ishibashi, Prof. of Kyoto University, Dr. T. Kamohara, Prof. of Kochi University and the Committee of Marine Productivity of the Japan Science Council for their helpful directions and other facilities afforded.

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STUDIES ON THE DIRECT MANUFACTURE OF SODIUM HYDROXIDE AND OTHER MATERIALS FROM SEA WATER (Part VI)

Effects of Magnesium and Calcium Ions—A Supplement

By
Taizo Kume, Takeo Hisano and Hideaki Izawa
(Faculty of Engineering, Tokushima University)

Supplemental experiments on the effects of magnesium and calcium ions were carried out. The electrolytic cell was the same as the previously reported except the cathode compartment. As the reproducibility of experimental results partly depended remarkably upon the manner of flow of mercury, the shape of cathode compartment was so altered as to let the mercury stream down as uniformly as possible. Check experiments showed that the new cathode, in the case of pure sodium chloride solution, gave somewhat more reproducible and slightly higher values of current efficiency than the old one. The cathode surface area was 5.5 sq. cm, and the layer of flowing mercury about 4 mm thick. All observations were made at 10～15°C and at pH of 6.8±0.1, and the velocity of mercury flow was 10～12 cc/min.

Results

In Fig. 1 is shown the relation between the current density and current efficiency for the formation of sodium hydroxide when 3% sodium chloride solutions containing magnesium chloride in various amounts were electrolysed. The curves are classified into two types, one bending upwards and the other downwards. Between these two, that is, in the region of intermediate concentration of Mg^{++}, there are curves extraordinarily difficult to reproduce. The curves for 0.4 and 0.43 g/L Mg^{++} in the figure are just a few examples of them. Fig. 2 shows the current efficiency for each current density plotted against the concentration of magnesium ions. The most striking feature is the sudden fall of the efficiency at the concentration of about 0.4 g/L Mg^{++}. In general the efficiency decreases with time of electrolysis. All values of current efficiency plotted here were determined by analysing Na-amalgam collected for 1 minute after 20～30 seconds from the beginning of electrolysis. After longer periods the values of current efficiency, in the case of 0～0.4 g/L Mg^{++}, fell on to the dotted lines in Fig. 2, the position of the whole curve more or less sliding down.

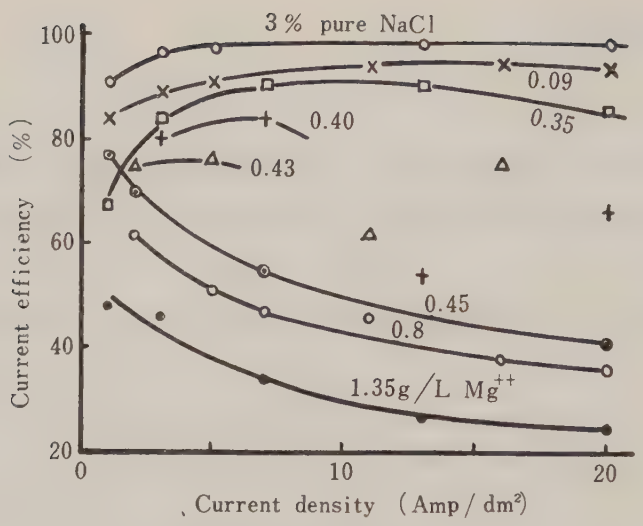

Fig. 1. Effect of Mg^{++}

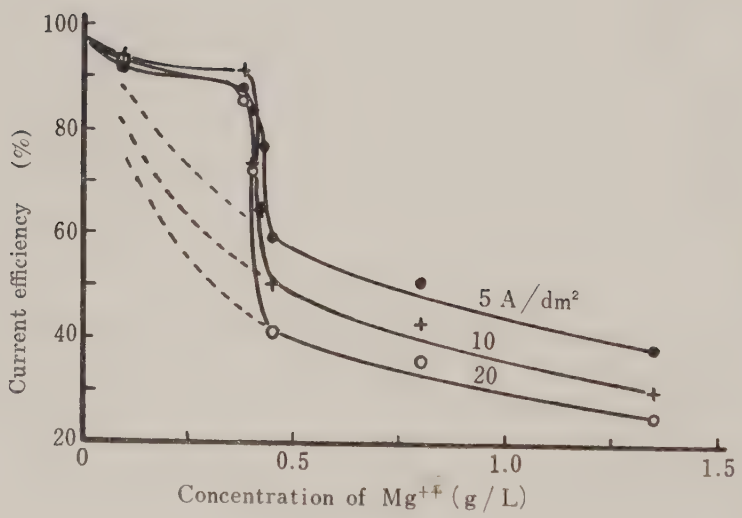

Fig. 2. Effect of Mg^{++}

From these experiments it seems to be inferable that the depreciation of current efficiency by magnesium ions is likely to be much related to the accumulation of some product, the formation or accumulation of which needs considerable time, though further evidence has to be obtained.

Since the values of current efficiency became poorly reproducible by the presence of calcium ions, mean values were taken to record the result in Fig. 3.

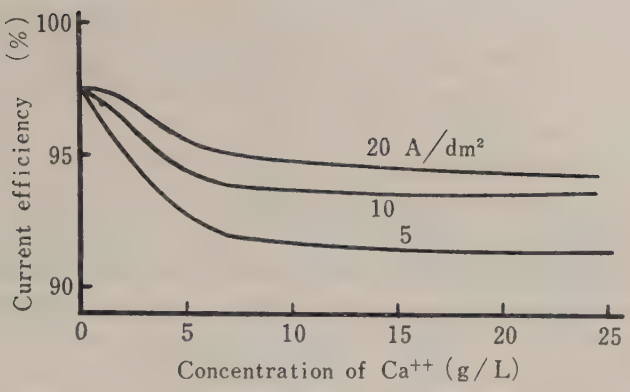

Fig. 3. Effect of Ca^{++}

The presence of Ca, even to the concentration of 25 g/L, is not more harmful than that of Mg^{++}. It is somewhat strange that the current efficiency increases together with current density in contrast with the case of Mg^{++}.

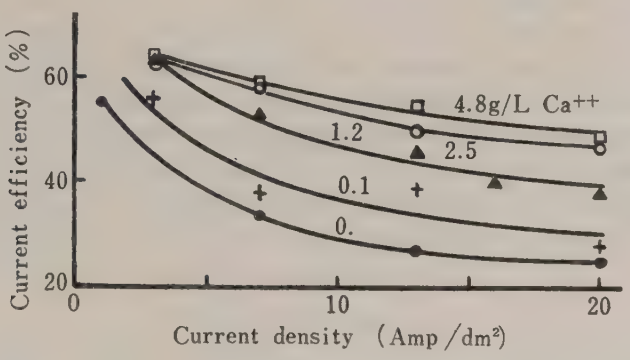

Fig. 4. Effect of Ca coexisting with 1.35 g/L Mg^{++}

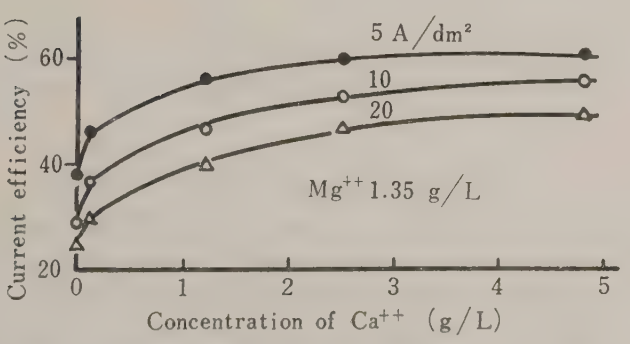

Fig. 5. Effect of Ca coexisting with 1.35 g/L Mg^{++}

Fig. 4 and 5 show the influence of Ca^{++} in various concentrations added to the 3% sodium chloride solution containing 1.35 g/L of Mg^{++}. In this case also mean values of divergent values were employed. The injurious influence of Mg^{++} is diminished by the presence of Ca^{++}.

Conclusion

In the electrolysis of dilute sodium chloride solution using a mercury cathode of small area such as 5 sq. cm or so, it seems to be difficult to obtain sufficiently reproducible values of the cathodic current efficiency. It is in particular so when Mg^{++} or Ca^{++} is present in the solution. This fact may be attributed mainly to the local and irregular stagnation of the flow of surface mercury. Overall velocity of the flowing mercury can be kept constant with ease, but the surface mercury does not always move along with the underlying part. The manner of flow of surface mercury is governed in a delicate and complicated way by the shape of cathode compartment, current density, concentration of co-existing ions, overall velocity of mercury, etc. Therefore, if the area of cathode is small, the influence of the irregular and local variation of the surface state will become relatively significant. Consequently it is considered that this leads to the poor reproducibility of the current efficiency.

As for the current efficiency, it will amount to considerably higher values than these reported here, provided that the flow of mercury is made sufficiently turbulent. This is to be expected by the experiment on the relation between current efficiency and the flow velocity of mercury (previously reported).

In any case, as the presence of more magnesium ions is more harmful and that of calcium ions less harmful, it will be desirable to minimize the concentration of magnesium ions by calcium ions.

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STUDIES ON MANUFACTURE OF MAGNESIUM HYDROXIDE FROM CALCIUM CARBIDE AND SEA WATER OR BITTER BRINE, AND ITS UTILIZATION (IV)

On Determination of pH of Reaction Medium and Effect of Size of CaC_2

By
Shiro Takashima
(Himeji Technical College)

Introduction

In the previous paper in 1957, the author described on comparison of direct method with indirect method; the former is the method of manufacturing C_2H_2 and $Mg(OH)_2$ by direct reaction of CaC_2 and $MgCl_2$ solution according to $CaC_2+MgCl_2+2H_2O=C_2H_2+Mg(OH)_2+CaCl_2$, while the latter is the method of obtaining $Mg(OH)_2$ from $MgCl_2$ solution and waste sludge of CaC_2 (reaction residue of C_2H_2 production from CaC_2 and H_2O) according to two reactions: $CaC_2+2H_2O=C_2H_2+Ca(OH)_2$ and $Ca(OH)_2+MgCl_2=Mg(OH)_2+CaCl_2$.

In the present paper, pH of reaction medium was determined to discuss why larger crystallites of $Mg(OH)_2$ were obtained by this direct method and the influence of size of CaC_2 on pH was also researched.

Experimental Procedure

The same sample of CaC_2 of 2nd grade as in the previous researches was used and little by little added into various concentrations of chemical pure $MgCl_2$ solution by "throwing method", and pH of medium was measured during reaction with a Horiba's pH-meter. At first, change of pH was determined in different concentrations at 20°C, then observation of influence of temperature on pH and comparison of pH with that of medium in indirect method at same conditions were carried out.

Experimental Results and Discussion

As seen in Table 1, pH of reaction medium of $MgCl_2$ and $Mg(OH)_2$ accorded with pH of $MgCl_2$ solution before reaction, and the value increased with addition of excess $Ca(OH)_2$ up to 11.0 which is equal to pH of $Ca(OH)_2$ solution. When equivalent $Ca(OH)_2$ was added enough to produce total $Mg(OH)_2$, pH showed a constant value 8.6 in 40% $CaCl_2$ solution.

Table 1. pH of medium dispersing $Mg(OH)_2$

Medium	pH
(1) Dispersion of $Mg(OH)_2$ in distilled H_2O	10.3
(2) Dispersion of $Mg(OH)_2$ in bitter brine ($MgCl_2$ $6H_2O$ 28.52%)	8.8
(3) The above bitter brine	8.6
(4) Dispersion of $Ca(OH)_2$ in the above brine	11.0
(5) Dispersion of $Mg(OH)_2$ in 40% solution of $CaCl_2$	8.6
(6) The above 40% solution of $CaCl_2$	6.4

The following figures show the change of pH with time during the reaction.

Influence of Concentration at 20°C

Changes of pH of medium with adding grains of CaC_2 little by little into each of $MgCl_2$ solutions of 0.3, 1, 20, 40 and 60%, were plotted in Figure 1.

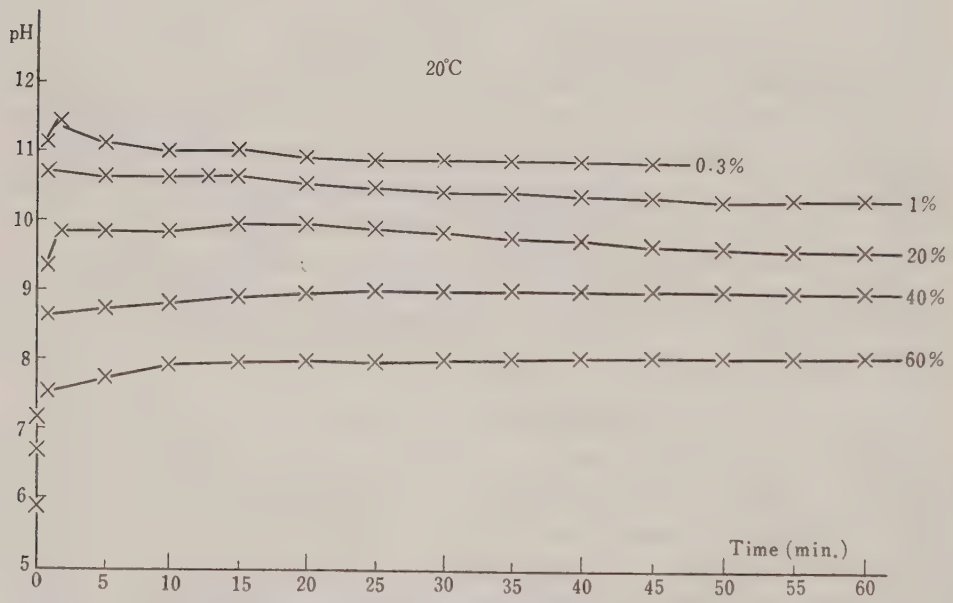

Fig. 1. Change of pH with time during reaction

(1) When grains of CaC_2 were thrown into $MgCl_2$ solution, pH of medium rose up to 7.5~11.2 from 5.6~6.4.

(2) Further, continuing to add grains of CaC_2, pH was constant for about 15 minutes, thereafter it decreased in cases of such lower concentrations of $MgCl_2$ as 0.3 and 1%; while in such higher concentrations as 40 and 60%, pH increased slowly up to a constant value after finishing to add all the equivalent of CaC_2, because the reaction proceeded very slowly.

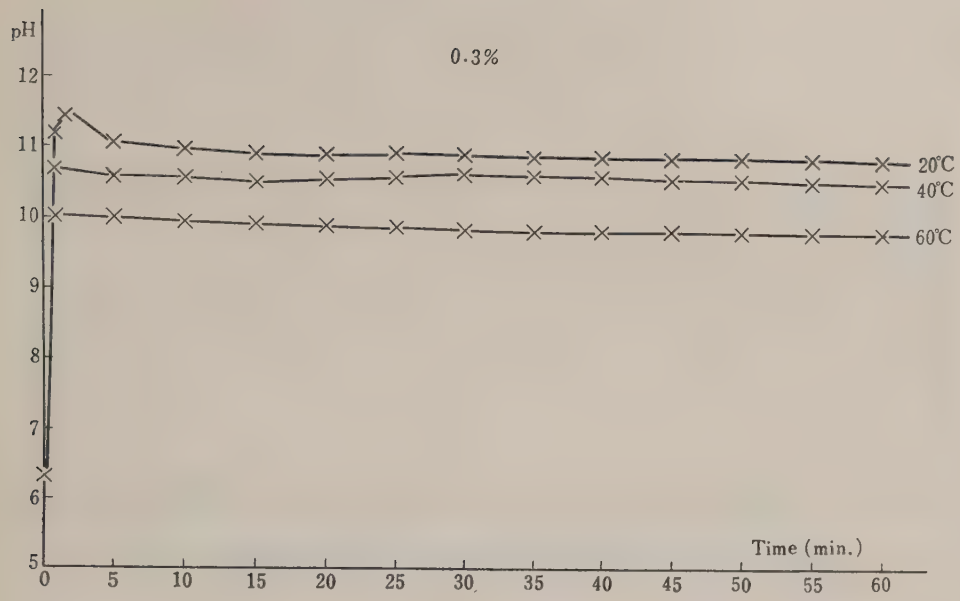

Fig. 2. Change of pH with time during reaction ($MgCl_2$ 0.3%)

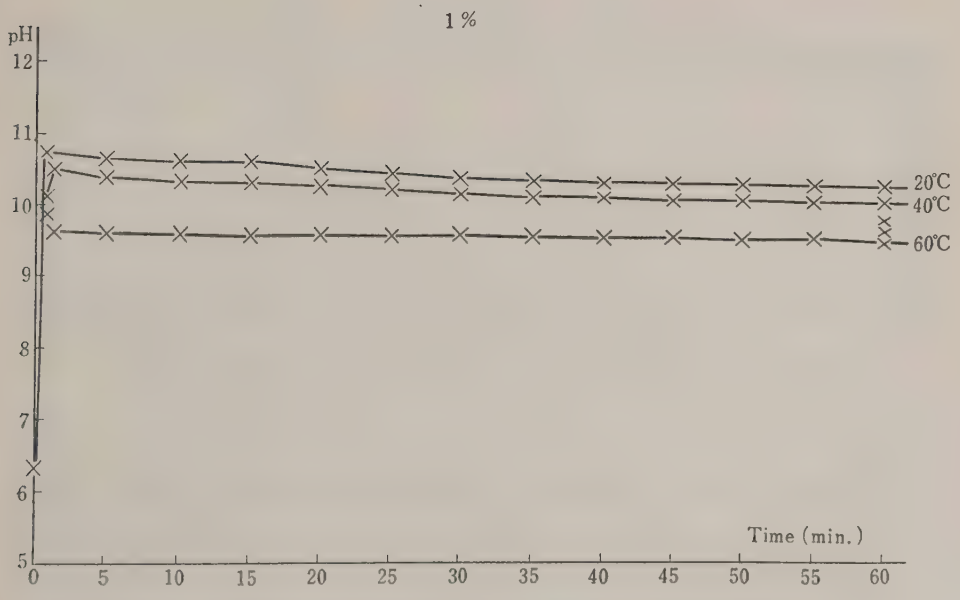

Fig. 3. Change of pH with time during reaction ($MgCl_2$ 1%)

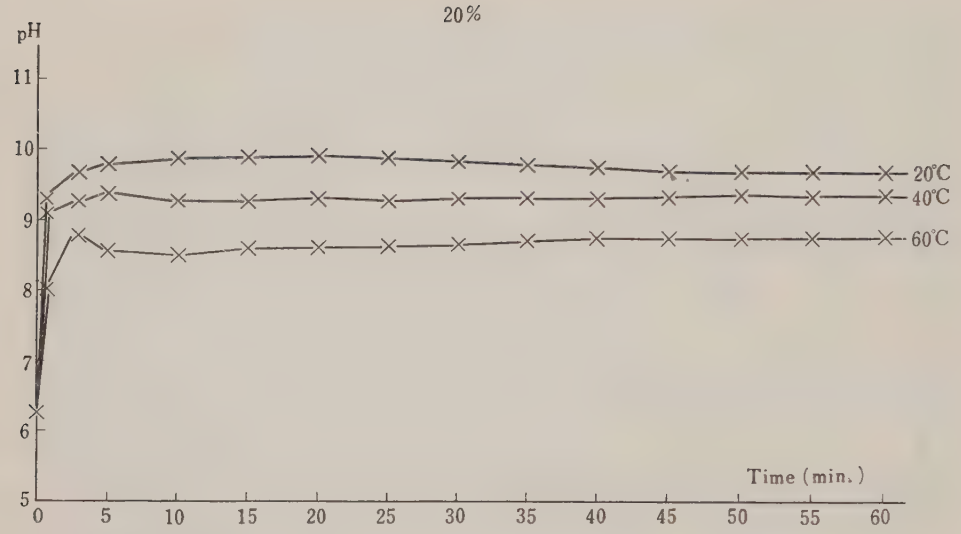

Fig. 4. Change of pH with time during reaction ($MgCl_2$ 20%)

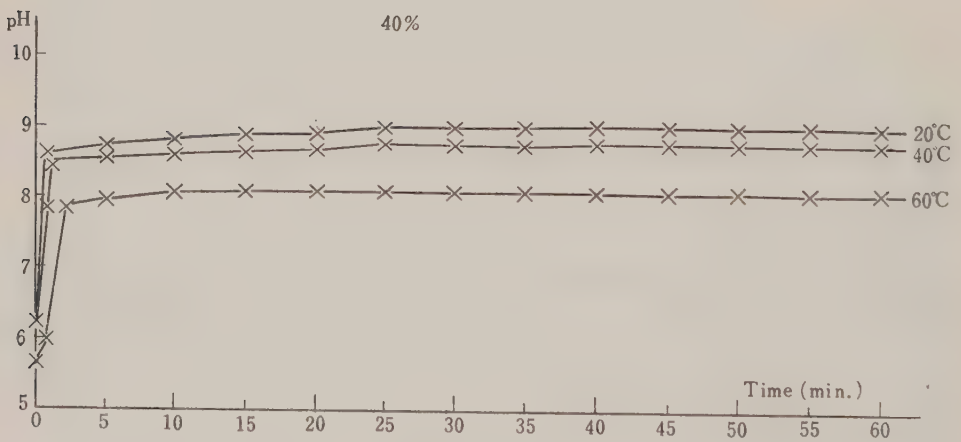

Fig. 5. Change of pH with time during reaction ($MgCl_2$ 40%)

(3) As to each case, adding grains of CaC_2 into $MgCl_2$ solution, pH of medium is 11.2 in 0.3% of $MgCl_2$ solution, 10.7 in 1%, 9.3 in 20%, 8.6 in 40% and 7.5 in 60%; that is, the higher the concentration of $MgCl_2$, the lower its pH.

These facts would be illustrated by assuming that in lower concentration of $MgCl_2$ solution the reaction of CaC_2 with H_2O under production of C_2H_2 is

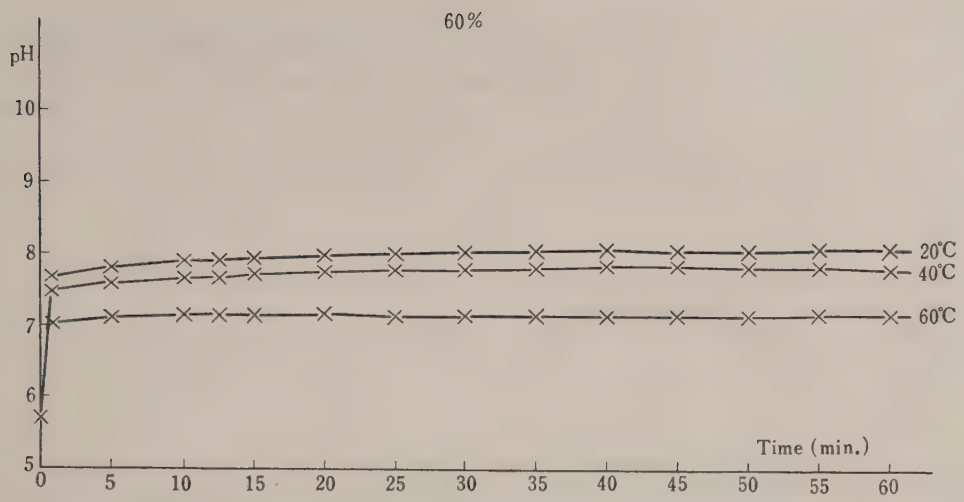

Fig. 6. Change of pH with time during reaction ($MgCl_2$ 60%)

very active and too much $Ca(OH)_2$ is produced to react with $MgCl_2$ at once, while in higher concentration the reaction proceeds more slowly and the content of free $Ca(OH)_2$ is so small that the value of pH is lower and the size of crystallite of $Mg(OH)_2$ becomes larger.

Influence of temperature

In each case of different concentrations, pH decreased with rising of temp. from 20°C to 60°C. (Ref. to Figs. 2, 3, 4, 5 & 6.)

The production of C_2H_2 was accelerated with temp., but solubility of $Ca(OH)_2$ would decrease with temp..

Besides it is thought that $Ca(OH)_2$ reacts comparatively fast with $MgCl_2$ to produce $Mg(OH)_2$ and the excess of $Ca(OH)_2$ may not be present. But such difference of temp. would give little influence on preparation of $Mg(OH)_2$.

In the previous paper the author described that the thickness of plane (001) increased with temp. in the case of 20% concentration, but decreased in 60% on the contrary and it was almost constant in 40%. These different effects of concentration could not be illustrated by determination of pH.

There would be thought two opposite effects of temp.. The one is a bad effect on the growth of $Mg(OH)_2$, which is caused by the fact that production velocity of C_2H_2 and $Ca(OH)_2$ increases with temp.; the other is a good effect that less solubility of $Ca(OH)_2$ in $MgCl_2$ solution at higher temp. causes the decrease of pH.

Therefore in lower concentration of 20%, such a fortunate factor as less solubility of $Ca(OH)_2$ may be preferable to another factor with higher temperature, while in higher concentration of 60% the undesirable factor such as increase of production velocities of $Ca(OH)_2$ and also of $Mg(OH)_2$ is preferable to the other.

Comparison with Indirect Method

In order to compare the above results with those in indirect method, milk of lime, which is the waste sludge obtained with production of C_2H_2 from CaC_2 and H_2O, was added into $MgCl_2$ solution instead of CaC_2 in direct method, and pH of medium was determined (Ref. to Fig. 7).

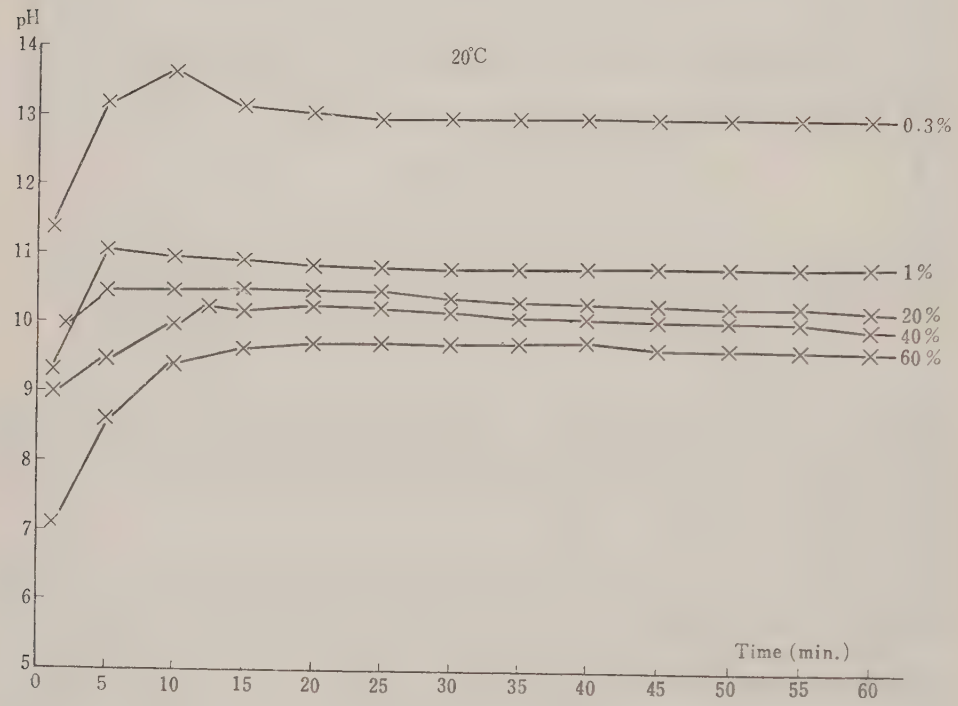

Fig. 7. Change of pH with time in indirect reaction (20°C)

Comparing them with the results in Fig. 1, values of pH were always higher than those in direct method. This is a matter of course, if we admit following three points that in indirect reaction the rising of temp. does not occur so much as in exothermic phenomenon of direct reaction; reaction medium of $Mg(OH)_2$ is diluted with milk of lime; and the reaction always has to proceed in excess of $Ca(OH)_2$.

Effect of Size of CaC_2

The direct method has two advantages that larger crystallites of $Mg(OH)_2$ are obtained from concentrated $MgCl_2$ solution such as bitter brine and more easily separated by filtration or sedimentation and also the product $Mg(OH)_2$ contains lower content of CaO than that from dilute solution of $MgCl_2$ such as sea water. But it has a disadvantage that rate of C_2H_2 evolution decreases with increase of concentration of $MgCl_2$.

In order to improve this disadvantage, besides heating effect, pulverized CaC_2 might be effective. Then the influence of size of CaC_2 was examined.

Three different sizes of CaC_2 were compared under 1 m.m. in dia., about 5 m.m. in mean size and about 10 m.m..

The rate of C_2H_2 evolution increased in the case of powdered CaC_2 as shown in Table 2.

Table 2. Influence of size of CaC_2 on C_2H_2 production by "Throwing method"

time (min.) / size of CaC_2	5	10	15	20	25	30
	c. c.	c. c.	c. c.	c. c.	c. c.	c. c.
under 1 m. m.	1690	2510	2770	2848	2858	2863
5 m. m. (mean)	1460	2250	2670	2826	2843	2848
10 m. m. (mean)	1655	2380	2618	2768	2791	2820

But the rate of filtration of $Mg(OH)_2$ from 20% concentration of $MgCl_2$ decreases in the case of powdered CaC_2. However pH is not influenced by size of CaC_2, because C_2H_2 occurs out of medium by surface reaction of CaC_2 and H_2O.

Summary

Experimental results are summarized as follows.

(1) In optimum concentration of $MgCl_2$ (20~40%), pH of this direct reaction can be kept constant, so that the size of $Mg(OH)_2$ seems to be equal.

(2) Larger crystallite of $Mg(OH)_2$ can be obtained by this method using CaC_2 as well as other method using such weak alkaline material as NH_4OH with low value of pH.

(3) At higher temperature, the rate of reaction is accelerated, but solubility of $Ca(OH)_2$ and also pH of medium decrease. (It may be thought that this reaction is of course exothermic and causes to rise reaction temp.)

(4) As to relation between size of crystallite of $Mg(OH)_2$ and pH of medium, the optimum value of pH is about 9, and under lower value of pH such as in higher concentration of $MgCl_2$, size of crystallite of $Mg(OH)_2$ becomes small.

(5) Size of CaC_2 has no influence upon pH of reaction medium but to pulverize CaC_2 is effective to accelerate the production of C_2H_2.

(6) In this method reaction is very interesting itself but the method is also very interesting from the industrial point of view.

In case of using such a concentrated $MgCl_2$ solution of 20~40% as bitter brine, some devices for making CaC_2 powder would be necessary for the production of C_2H_2.

In addition the product $Mg(OH)_2$ contains higher content of impurities except CaO, so purification and utilization of such by-product should be studied.

In conclusion this method has following advantages:

(1) Utilization of sea water or bitter brine on the CaC_2 or C_2H_2 industry:
(2) Manufacture of $Mg(OH)_2$ by the reaction at constant pH which is difficult with other basic sources, but is necessary to get larger crystallite of $Mg(OH)_2$:
(3) Manufacture of $Mg(OH)_2$ with lower content of CaO, because this direct reaction can proceed under evolution of C_2H_2 which prevents $Ca(OH)_2$ from reacting with CO_2 in air and from making insoluble $CaCO_3$ in $Mg(OH)_2$.

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NOTES ON FISHES FROM THE PATH OF THE "KUROSHIWO" WITH SPECIAL REFERENCE TO THE ADAPTATION OR PREFERENCE OF SOME FLYING-FISHES FOR COOL WATER

By

Tokiharu Abe

(Tokai Regional Fisheries Research Laboratory, and Zoological Institute, Faculty of Science, University of Tokyo)

During the fiscal year 1958 (April 1, 1958~March 31, 1959), the writer visited the peninsulas of Izu and Kii as in the previous years, and further made a trip to the south-western part of Shikoku gathering fish specimens and information for the study of the annual changes in the elements of the piscifauna of the path of the "Kuroshiwo". Moreover, many specimens of fishes from the path of the current have been received for study from the fishermen and biologists who have kindly continued to cooperate with him since 1950. He takes pleasure in presenting here some of the results of his study done during the fiscal year 1958 aided by a grant-in-aid from the Japanese National Commission for Unesco and in expressing here his sincere thanks to the commission and Mr. B. Araya (Japan Society for the Promotion of Science) for their courtesy and to many of the friends of the writer for their cooperation.

Adaptation or Preference of *Cypselurus pinnatibarbatus japonicus* for Cool Water

As stated in previous papers (Abe, 1954; Abe, 1957), *Cypselurus pinnatibarbatus japonicus* (Franz) is one of the most important form of the flying-fishes taken commercially in the Japanese waters. It reaches the largest size, and has the largest number of vertebrae among the Japanese flying-fishes. In a single island of Hachijō, its annual landings since 1956 have been more than one thousand metric tons as shown in Table 1 (for those of 1950~1955, *vide* Abe, 1953; Abe, 1954; Abe, 1957).

The records given in Table 1 have been kindly gathered by Mr. T. Kusakari (Hachijō Branch, Tokyo Prefectural Fisheries Experiment Station), and comprise mostly the catches of the fish from near the coast of Hachijō Island and include those from a little southerly waters near Aogashima. After the breeding season near Hachijō during the period of February through May, when

Table 1. Annual landings [number of individuals and approximate weight in metric tons (in parentheses)] of *Cypselurus pinnatibarbatus japonicus* (Franz) in Hachijō Island since 1956

1956	Landed*	February 22 — May 14	3963577 (1,664.7)
1957	„	February 10 — May 16	3097224 (1,300.8)
1958	„	January 27 — May 11	4230248 (1,776.7)
1959	„	February 5 — May 5	3226938 (1,353.3)

the surface temperature of the sea near the island first reaches the minimum and then rises, this flying-fish is taken commercially off the eastern coast of Bōsō Peninsula for a few weeks. The barbelled young of this fish, measuring less than 150 mm in total length, have been collected near, or, a little north of Hachijō in May. From that time until the reappearance of the adult in September in Sagami Bay, off the eastern coast of Bōsō Peninsula and off the southern coast of Kii Peninsula, this flying-fish, either young or adult, has never been recorded. Since September the adult of this fish seem to migrate southward approaching the south-eastern coast of Kyūshū from November through February. The surface temperature of the coastal water there, after Imai (1959), is around 21°C in November and around 18°C in January～February. The fish spawns there in December and January. Near Hachijō Island, the sea surface temperature at the beginning of the fishing season of this flying-fish (when it approaches the island to spawn) is said to be around 18°C or 19°C, and the writer observed this in February, 1952. In view of the fact that the spawning seasons of the other flying-fishes commercially taken in the Japanese waters begin from late spring through late summer, it may be said that *Cypselurus pinnatibarbatus japonicus* prefers cool water for spawning.

Now, in autumn, 1958, two unbarbelled young of this fish measuring not less than 200 mm in total length were taken in northern Japan; one sailed on deck of the research vessel "Tenyo-maru" at 37°30′N, 145°50′E (sea surface temperature 16°C, after the captain, the late Mr. S. Sakai), on November 6, and the other was taken by a trap net set near Hakodate**, Hokkaidō, during the first decade of October. The former specimen measures *ca.* 200 mm in total length, and the latter 265 mm in total length. Thus it may be said that the

* The spring flying-fish of Hachijō Island, namely, *Cypselurus pinnatibarbatus japonicus* (Franz), is taken by drifting gill-nets in the night, and usually landed in the next morning

** Mr. K. Kobayashi (Faculty of Fisheries, Hokkaidō University) has kindly informed that there were several trap nets (primarily for the anchovy) near Hakodate set during October every year, and that the mean surface temperature of the sea near the pier of the Hakodate Dock during the first decade of October, 1958, was (after Hakodate Marine Observatory) 17.5°C (1.1°C lower than the mean of the previous years' records for October 1–10). The mean air temperature at the observatory during the first decade of October, 1958, was 12.7°C (0.4°C lower than the mean of the previous years' records for October 1–10). The writer expresses here his sincere thanks to Mr. Kobayashi for his cooperation.

young of this flying-fish (like the spawning adult) are adapted for, or prefer cool water, although the adult's whereabouts in summer are not known*.

Adaptation of *Danichthys rondeleti* or Its Close Ally for Cool Water

In 1958, Parin recorded the occurrence of *Danichthys rondeleti* (Valenciennes) in the north-western Pacific, from the water of 15.5°C, in May, 1955. This is in line with the statement of the present writer (Abe, 1956) that this species or its close ally is found in cool water. It is interesting to see that this flying-fish is found not only in cool water but also in warm water in midsummer near Tokyo. Early in April, 1954, the writer collected two young examples measuring less than 100 mm in total length of *rondeleti* or its close ally and two adult examples with well developed gonads, probably of the same species, near Hachijō Island, and around July 20 of the same year, two adult examples probably of the same species were taken by a trap net off Itō (western part of Sagami Bay), and have been received by him. It may be added here that the account given by Bruun (1935) also shows that *rondeleti* is found in cool water in the Atlantic.

Annual Changes in the Elements of the Piscifauna and Abundance of Fishes in the Path of the "Kuroshiwo"

In summer, when the "Kuroshiwo" reaches further north than in the other seasons, the commercial fish catch in the southern piscifaunal area (defined by Tanaka, 1931) decreases in amount, and the annual changes in the elements of the fauna are remarkable. Of the flying-fishes taken commercially in the Japanese waters**, those taken in summer are much less in amount than in spring†. But the number of the species or subspecies of these fishes is much higher in summer. They are: *Prognichthys agoo* (Temminck & Schlegel), *Cypselurus poecilopterus* (Valenciennes), *Cypselurus heterurus döderleini* (Steindachner), *Cypselurus opisthopus hiraii* Abe, *Cypselurus starksi* Abe, *Cypselurus atrisignis* Jenkins and *Cypselurus antoncichi* Woods & Schultz. The appearance of the last named species and *Cpyselurus katoptron* (Bleeker), and more especially of the latter, is sporadic; the latter was found since 1950 only in a year, 1953, and *antoncichi* is taken commercially in midsummer near Hachijō Island when the sea surface temperature remains at 29°C at least for a few days. The amount of the catch of *antoncichi* fluctuates considerably from year to year.

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* As for the migration of the adult of this flying-fish from Kyūshū to Hachijō Island, *vide* Abe, 1957, p. 95.

** Annual landings of flying-fishes in Japan exceed 10,000 metric tons.

† In Hachijō Island and several islands lying between Sagami Bay and Hachijō Island, the annual landings of the summer flying-fishes were 42.6 metric tons while those of the spring flying-fishes were 2,201.0 metric tons in the fiscal year 1958.

Of the two forms of mackerels, *Pneumatophorus japonicus japonicus* (Houttuyn) and *P. japonicus tapeinocephalus* (Bleeker), the former becomes scarce in summer just south of the boundary between the northern and southern piscifaunal areas, namely, south of Cape Inubō, and is taken in large quantity in northern Japan, both in the Pacific and in Japan Sea. The other mackerel, *tapeinocephalus*, prefers warmer water, and seems not to spawn near the boundary of the piscifaunal areas just mentioned. Its young of some 100~300 mm total length appear in the path of the "Kuroshiwo" in varying abundance. Unlike in 1957, the young of *tapeinocephalus* were not caught in large amount in warm seasons near the southern tip of Kii Peninsula. Whether the abundance of the young of this form in a year has bearing on the amount of the catch of its young of larger size or adult in the next year is not known.

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PRELIMINARY REPORT ON DIURNAL FEEDING ACTIVITIES OF GENUS SAURIDA

By
Tomo'o Hayashi, Yoshiaki Yamaguchi and Tasuku Hanaoka
(Inland Sea Regional Fisheries Research Laboratory)

Authors treated with the tropho-dynamic relation between benthic-piscivor and its prey around the Inland Sea and its adjacent region of the Pacific Ocean. In a part of the previous report (HANAOKA et al., 1959), they analysed the food niches of two genera of piscivor, Saurida and Synodus, as a fundamental try to orientate the trophic level of piscivor in the biotic community through analysis of stomach content.

Here, they preliminarily analysed the diurnal changes found in weight and composition of stomach contents of genus Saurida, a dominant benthic piscivor, around the Kii-channel and the Inland Sea, Japan.

Further try to analyse the feeding activities of piscivor will be done on the collection of experimental houlings carried out subsequently for 24 hours by a 2-boat-trawler operated during the June-cruise in 1959.

Materials and Methods

The three species which belong to genus Saurida are found around the Inland Sea, namely:

Saurida elongata (T. et S.)	"TOKAGE-ESO"
Saurida undosquamis (RICHARDSON)	"MA-ESO"
Saurida tumbil (BLOCH)	"WANI-ESO"

Relatively speaking, the first species lives in the neritic region, the third in the off-shore, and the second in the middle.

Among the numerous samples of genus Saurida collected from the Inland Sea and its adjacent region of the Pacific Ocean (Fig. 1), the following three sets of samples were studied here:

(1) Samples of genus Saurida collected in daytime by scheduled seasonal eight cruises of 2-boat-trawler of medium size (30 tons & 80 HP.s), over the eastern four sea regions "NADA"S, around the Kii-channel (A–D in Fig. 1). (Table 1)

(2) Samples collected during night from landing by beam-trawlers of small size (3~5 tons & 5~13 HP.s) around the five sea regions (B–F in Fig. 1), in similar areas as above. (Table 2)

Table 1. Scheduled seasonal cruises during daytime by the 2-boat-trawler

Cruise	Date	Number of				
		5.01 ~6.00	6.01 ~ 7.00	7.01 ~ 8.00	8.01 ~ 9.00	9.01 ~ 10.00
1 st	22, Sept. ~ 3, Oct., 1954	—	3	4	2	3
2 nd	23, March ~ 3, April, 1945	—	2	1	3	1
3 rd	3, June ~ 12, June, 1955	—	3	1	1	2
4 th	21, Aug. ~ 29, Aug., 1955	—	1	2	3	3
5 th	25, Jan. ~ 3, Feb., 1956	—	—	2	4	2
6 th	18, July ~ 26, July, 1956	1	2	3	1	3
7 th	26, Aug. ~ 3, Sept., 1956	—	2	3	3	3
8 th	2, Nov. ~ 7, Nov., 1956	—	2	2	6	3
		1	15	18	23	20

Table 2. Collections from landing by beam trawlers of small size, operated during night around the eastern Inland Sea (B—F in Fig 1)

Area	Landing port	Date	Collector
B. Kii-channel	Tokushima	Nov., 1955 ~ Sept., 1955	Tokushima Pref. Fish. Exp. St.
C. Osaka-bay	Osaka	Aug., 1957 ~ Nov., 1957	Osaka Pref. Fish. Exp. St.
D. Harima-nada	Mokake	July, 1957 ~ Sept., 1957	Okayama Pref. Fish. Exp. St.
E. Bisan-seto	Marugame	June, 1955 ~ Sept., 1957	Kagawa Pref. Fish. Exp. St.
„	Yorishima	June, 1955 ~ Aug., 1957	Okayama Pref. Fish. Exp. St.
F. Hiuchi-nada	Kanonji	June, 1955 ~ Nov., 1957	Kagawa Pref. Fish. Exp. St.

(3) Samples of *Saurida elongata* collected in the neighbouring day and night from the three localities in the Inland Sea (localities 1~3 in Fig. 1). (Table 3)

The samples of genus Saurida were preserved in 10% formalin solution immediately after each net-hauling. In the laboratory the contents were removed from the stomachs, and the food organisms were weighed after the lowest

Table 3. *Saurida elongata* collected by day and by night in the

Locality	Date of collection
1. The Eastern part of Hiuchi-nada	Day, 21 May, 1958
„ „	Night, 20–21 May, 1958
2. The Northern part of Aki-nada	Day, 22 May, 1958
„ „	Night, 20–22 May, 1958
3. The Eastern part of Suō-nada	Day, 27 May, 1958
„ „	Night, 29–30 May, 1958

of medium size around the eastern Inland Sea (A—D in Fig 1)

hauls by time									
10.01 ~ 11.00	11.01 ~ 12.00	12.01 ~ 13.00	13.01 ~ 14.00	14.01 ~ 15.00	15.01 ~ 16.00	16.01 ~ 17.00	17.01 ~ 18.00	18.01 ~ 19.00	Total
1	2	2	3	3	1	1	2	—	27
—	2	1	3	1	—	1	—	—	15
3	2	3	2	1	—	2	—	—	20
1	2	3	3	3	1	3	—	—	25
4	4	3	3	4	1	2	—	—	29
3	4	3	—	3	3	—	1	—	27
4	4	2	2	5	1	2	—	1	32
5	4	4	2	2	—	1	—	—	31
21	24	21	18	22	7	12	3	1	206

category to which they could be identified to belong, and body length and weight of predators are studied with the identification of sex.

The individual– (f) and the group– (F) weight index of stomach contents were defined as follows:

$$f = \frac{\text{S. C. W.}}{\text{B. W.} - \text{S. C. W.}} \times 100 \quad (\%) \qquad (1)$$

$$F = \frac{\Sigma\,\text{S. C. W.}}{\Sigma\,\text{B. W.} - \Sigma\,\text{S. C. W.}} \times 100 \quad (\%) \qquad (2)$$

where B.W. and ΣB.W. are the body weights of individual and total predators, and s.c.w. and Σs.c.w. the weights of their stomach contents, respectively.

The group weight index of stomach contents (F) and the percentage frequency of f-value were used here as the index of feeding activities of the predators. The composition of stomach contents was used to compare the prey organisms captured by the predators by day and by night.

neighbouring days from the three localities (1—3 in Fig 1)

No. of individuals of *Saurida elongata*	Fishing boat and gear	Observers
125	2 boat trawler, medium size	Present authors
10	beam trawlar, small size	Staffs of KAGAWA Pref. Fish. Exp. St.
222	2 boat trawler, medium size	Present authors
48	beam trawler, small size	Staffs of HIROSHIMA Pref. Fish. Exp. St.
139	2 boat trawler, medium size	Present authors
30	beam trawler, small size	Staffs of YAMAGUCHI Pref. Fish. Exp, St.

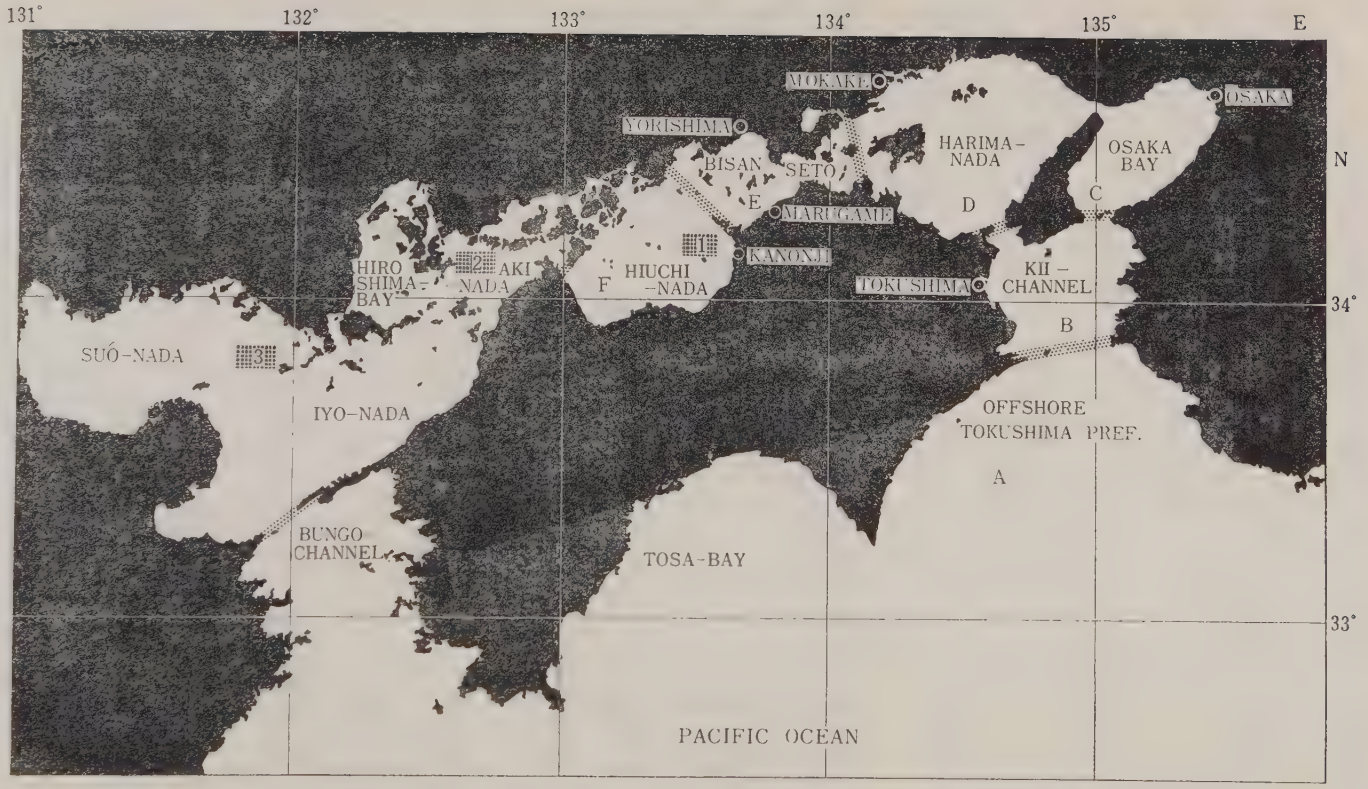
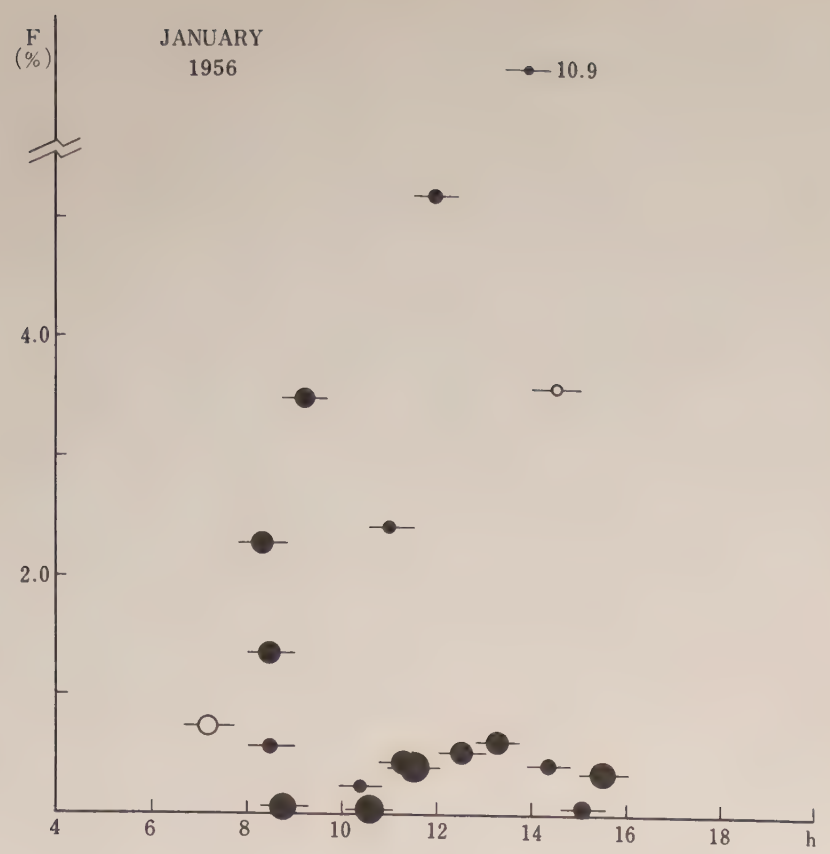
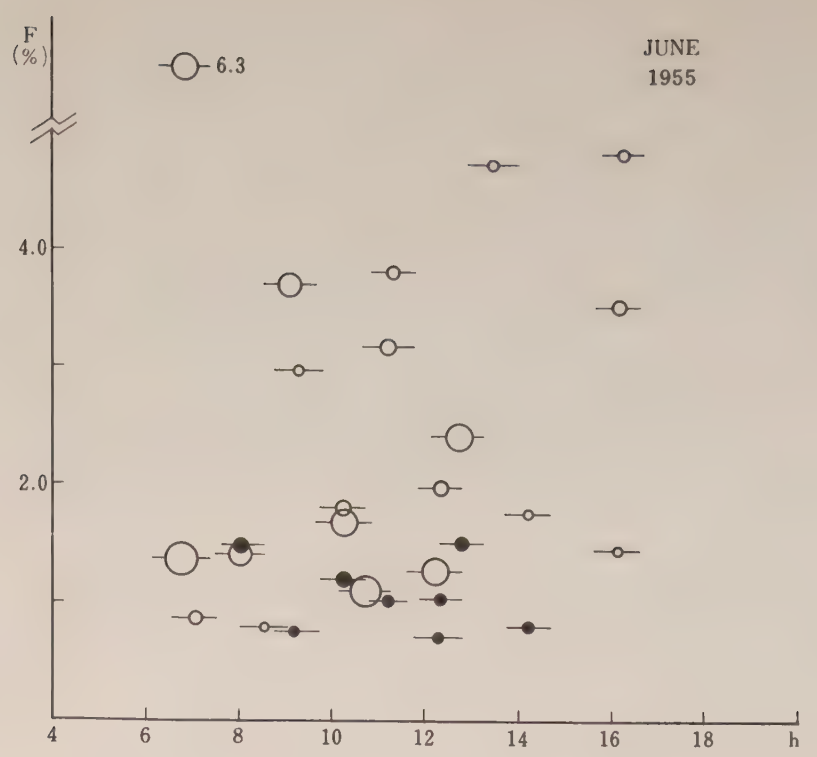
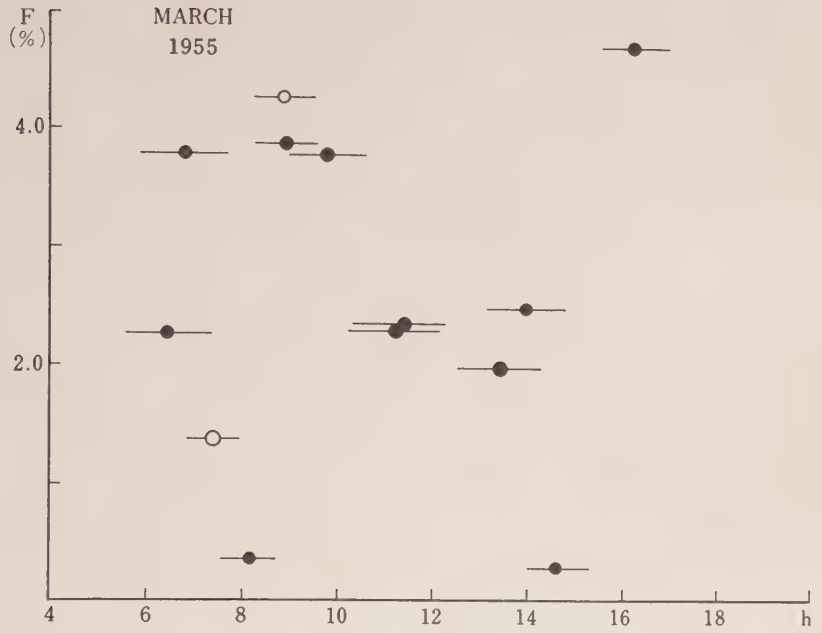


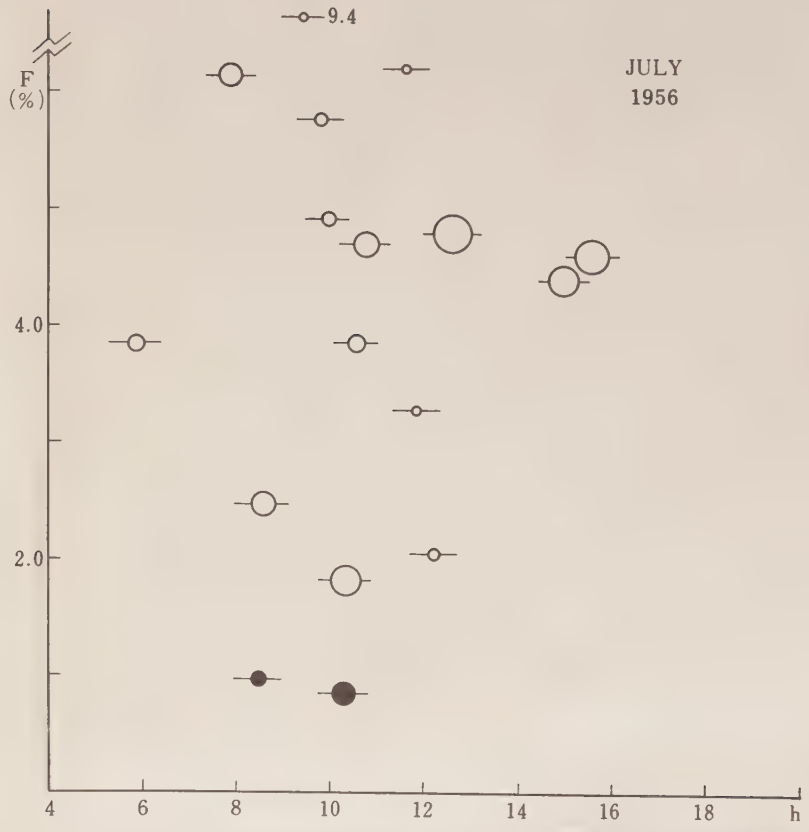
Fig. 1. The Inland Sea and adjacent region of the Pacific Ocean, showing the sea regions ("NADA"s) and the localities of collections of genus Saurida.

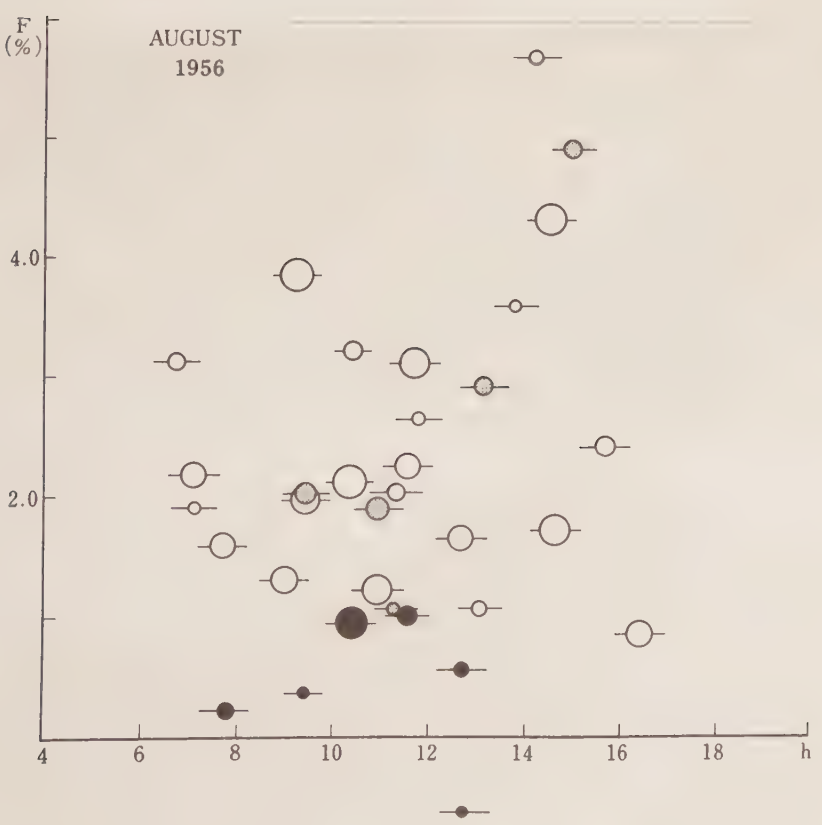
A–F show the sea regions of collections in Tables 1 and 2. 1–3 show the three localities of collections in Table 3.

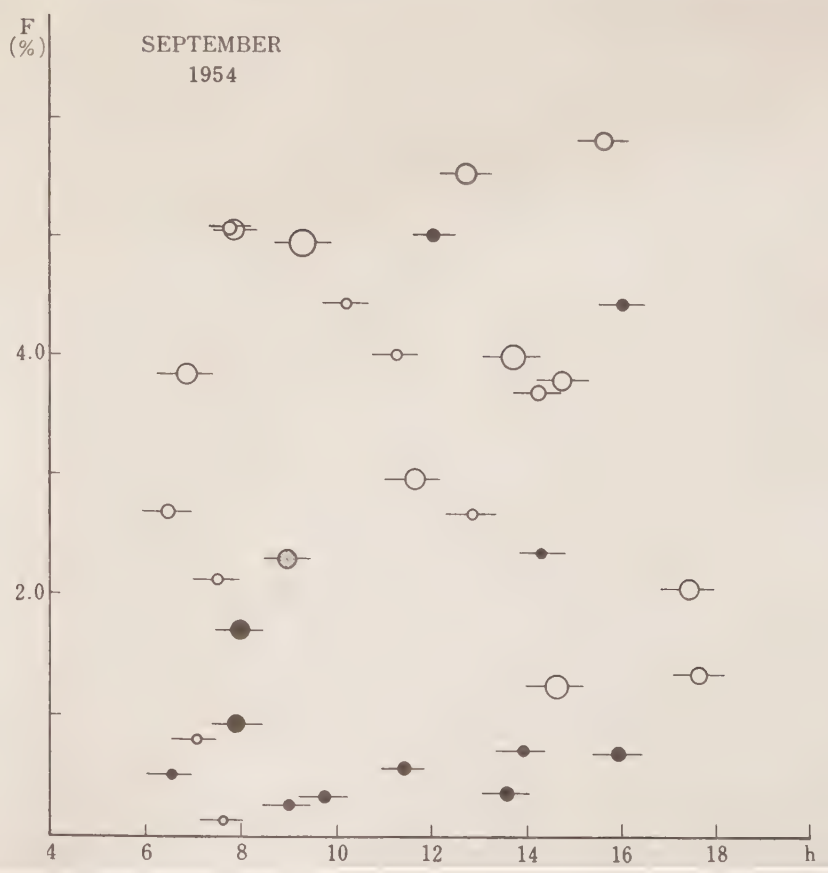


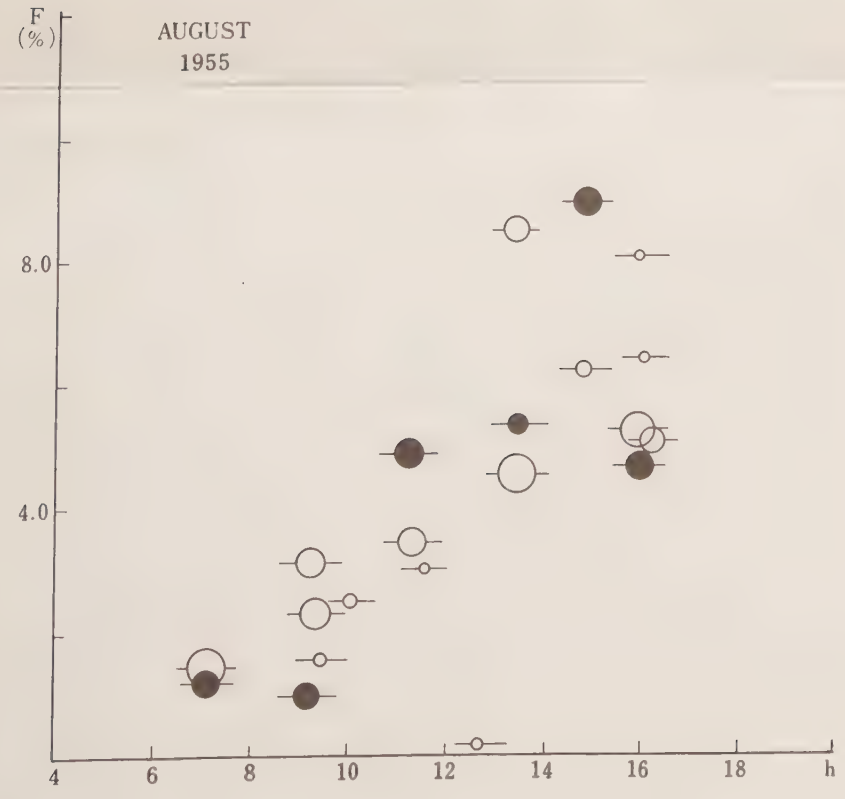












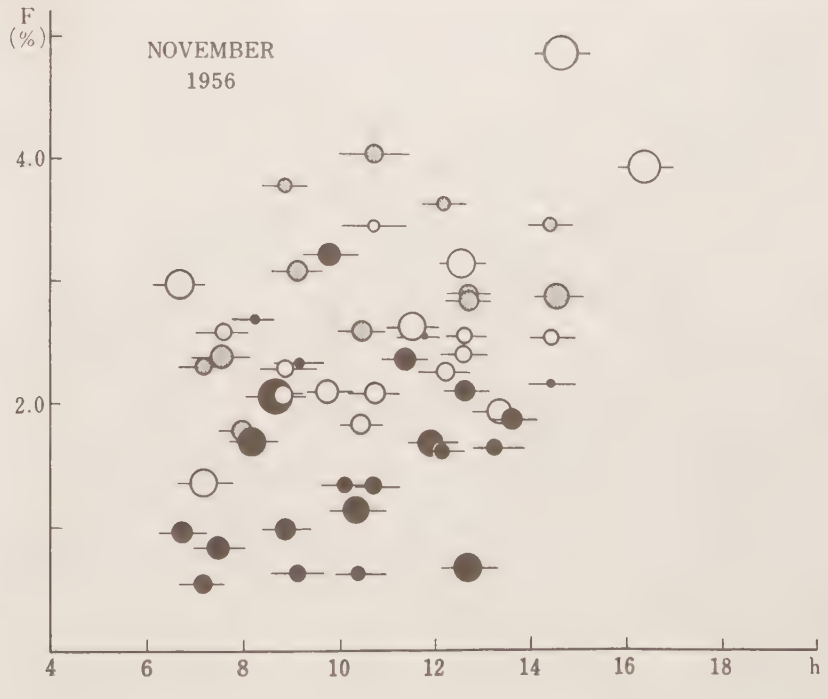


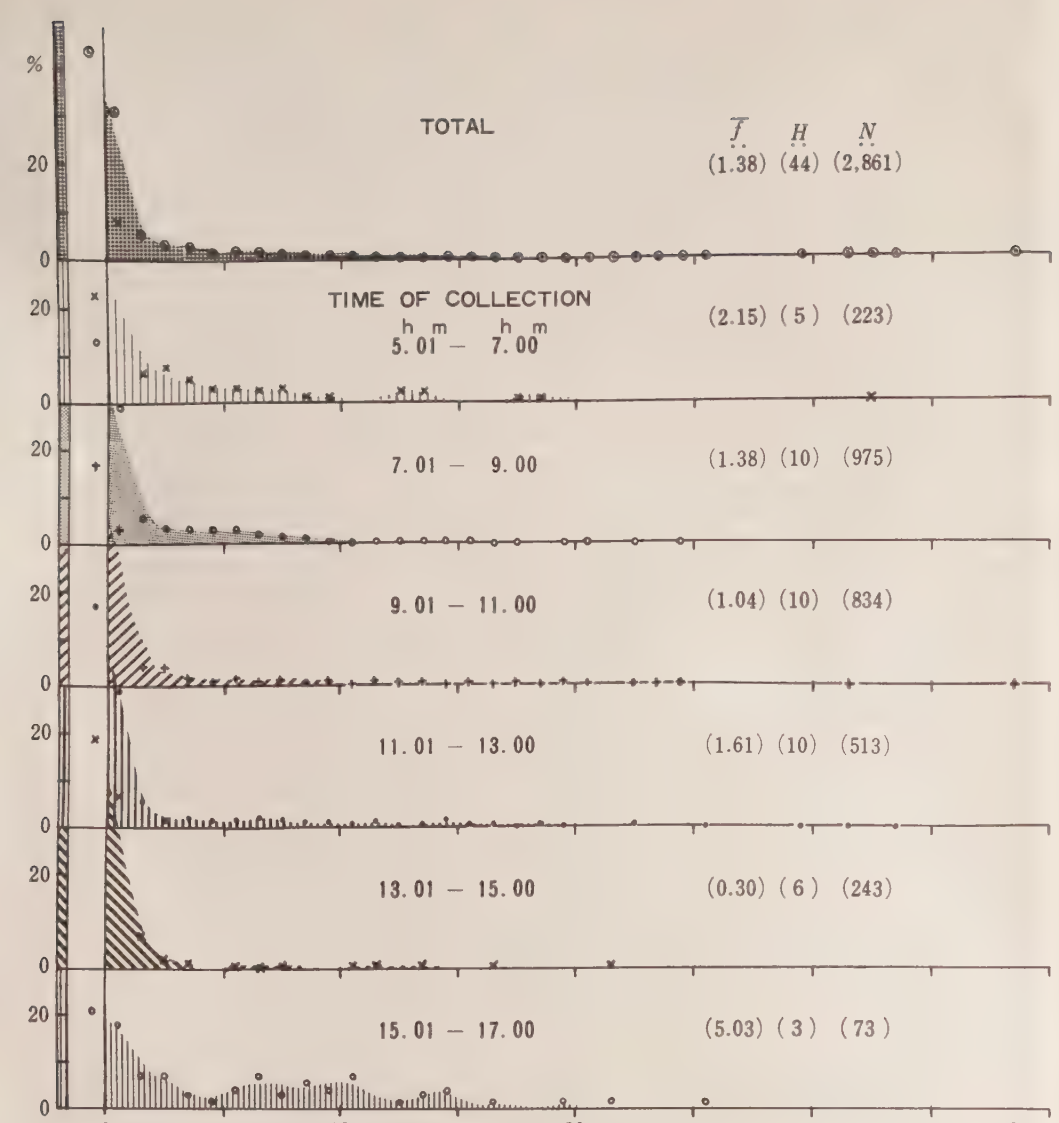
Fig. 2. Group weight index of stomach contents ($F=\Sigma s.c.w./\Sigma B.W.-\Sigma s.c.w.$) of the three species of genus Saurida collected by the eight seasonal cruises, by the time of collection in the daytime.

ΣB.W.: Aggregated body weight of predators, Σs.c.w.: Aggregated weight of stomach contents.

○ *Saurida undosquamis* ● *S. elongata* ⊗ *S. tumbil*

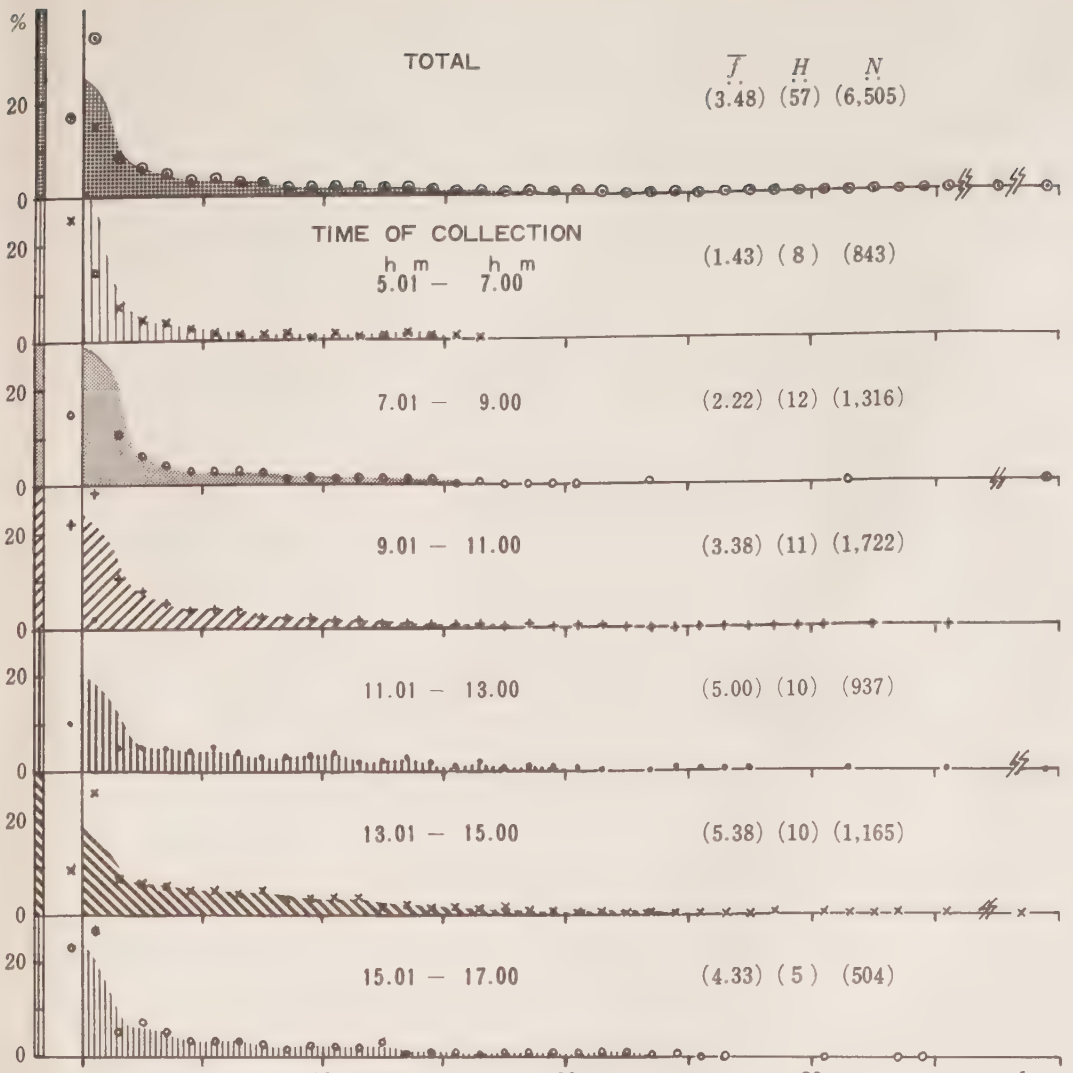
Areas of circles show numbers of predator [N=100 50 20 ○ ○ ○]

Length of horizontal lines show the time-durations of net-hauling of 2-boat-trawler



January & March

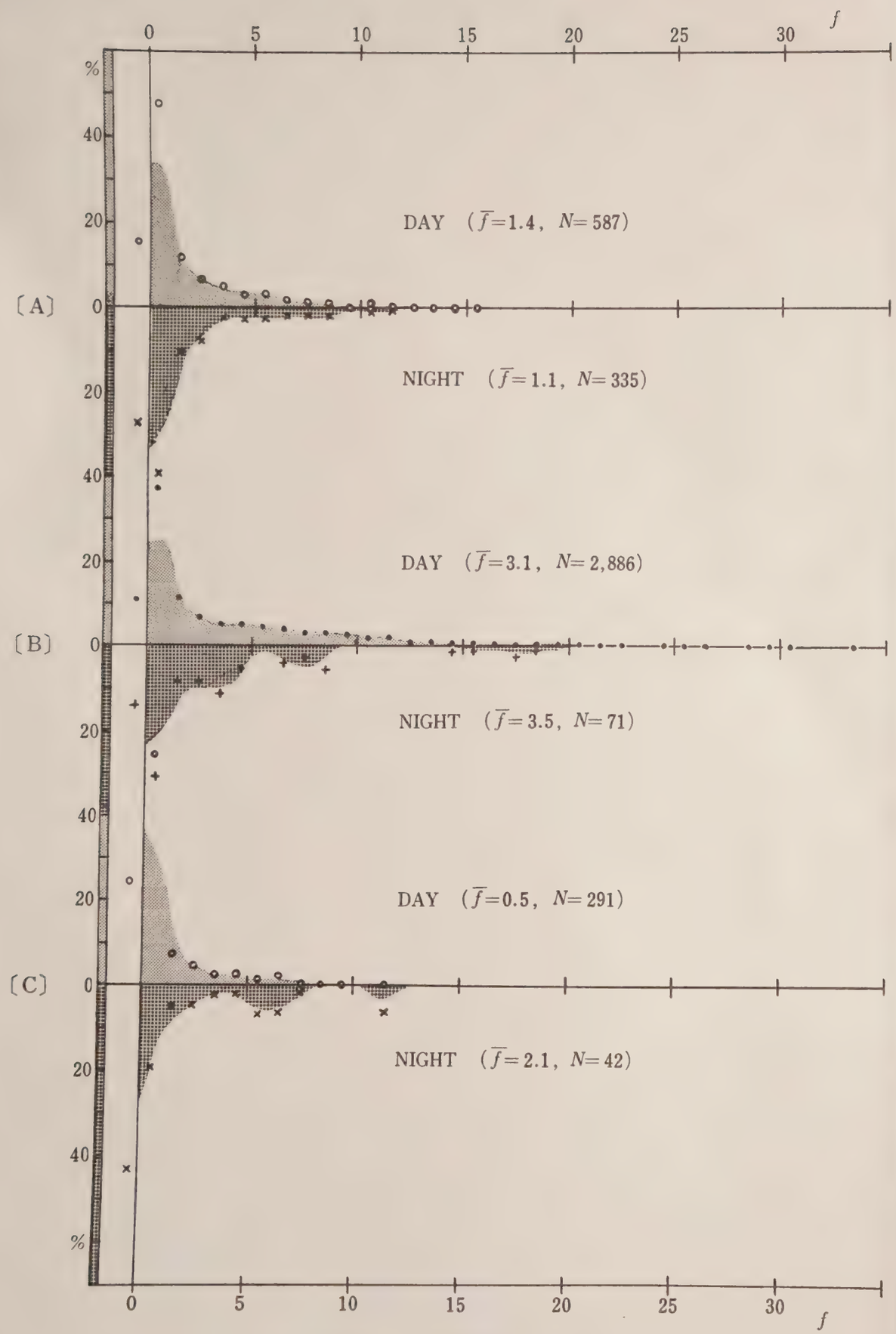
June & July



August, 1955 & 1956

September & November

Fig. 3. Percentage frequency of individual weight indexes of stomach contents (f) by the time in the daytime
f=s.c.w./B.W.–s.c.w.×100%, $\bar{f}$=mean of f-value, f=0: Empty stomach
The time of collection is classified by the middle time of every net-hauling. H: Number of net-hauling,
N: Number of individuals of predators.



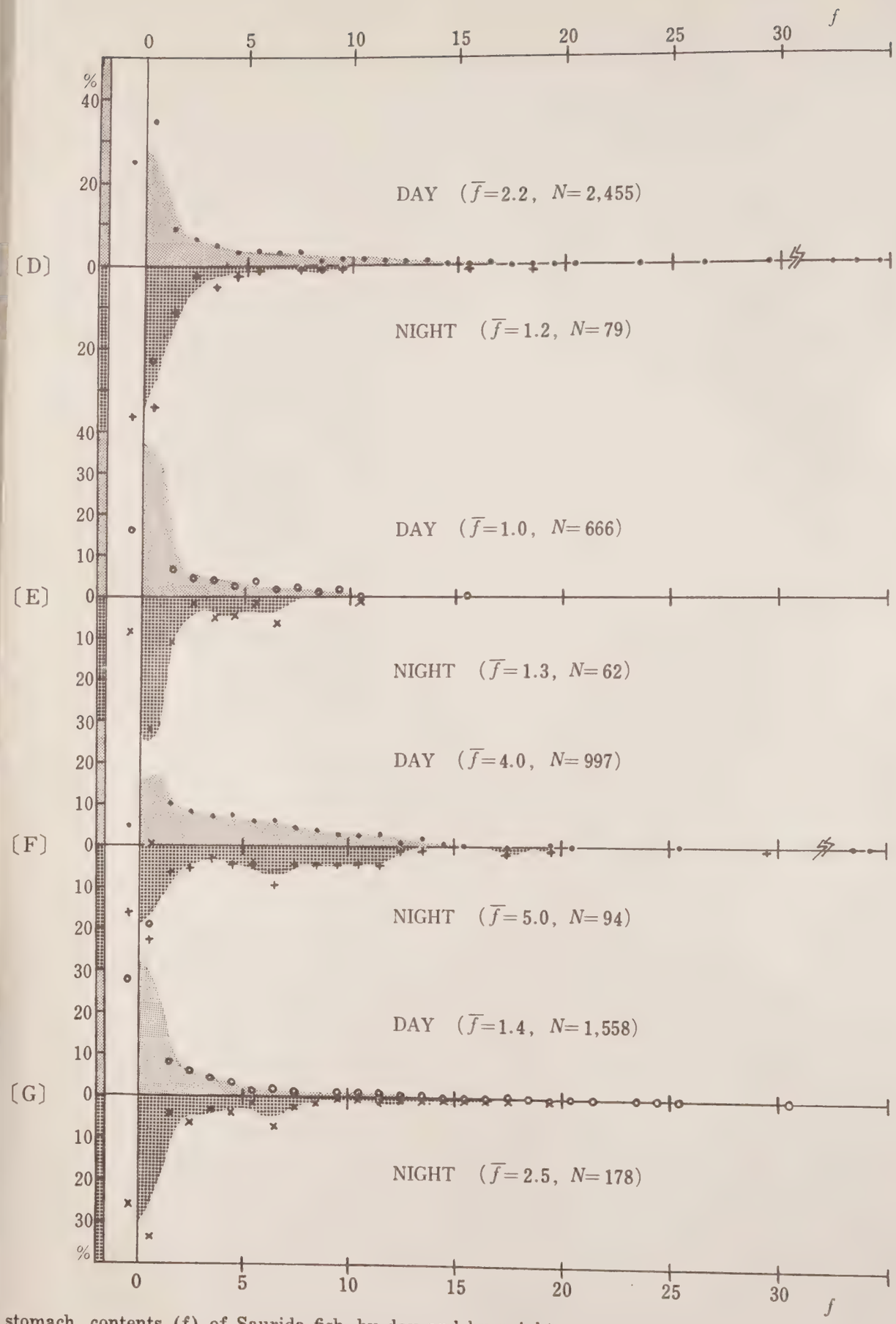


Fig. 4. Percentage frequency of individual-weight index of stomach contents (f) of Saurida fish, by day and by neight.
[A]: June–July, *Saurida elongata*
[B]: June–July, *Saurida undosquamis*
[C]: August, *S. elongata*
[D]: August, *S. undosquamis*
[E]: September, *S. elongata*
[F]: September, *S. undosquamis*
[G]: November, *S. elongata*

Results

Weight of Stomach Contents by the Time in Daytime

Although the time of net-hauling in the scheduled cruises of 2- boat- trawler was restricted in the daytime, the times of beginning and end of every net-hauling were recorded. The group weight index of stomach contents (F) of the three species of Saurida collected by each hauling is shown in Fig. 2, and the percentage frequency of the individual weight index, f-value, in Fig. 3 by the time of collection.

Group weight index, F-value, of each hauling varies widely at any time and it seems to be difficult to find a distinct tendency of changes in F-value with time except on the samples collected during the August 1955 cruise. (Fig. 2)

Percentage frequency of f-value shows somewhat characteristic patterns according to the seasons of sampling cruises, but little difference according to the time of collection. (Fig. 3)

These might mean that genus Saurida, a dominant genus among benthic piscivor, feeds on prey intermittently regardless of the time in the daytime (Fig. 1), and its feeding activity does not vary significantly during the daytime.

Weight of Stomach Contents by Day and by Night

The samples of genus Saurida were collected during night at several ports from the landing of beam-trawlers of small size, which haul their nets twice a night but able to get few piscivors because of the low efficiency of the fishing gear.

Fig. 4 shows the percentage frequency of individual weight indexes of stomach contents (f) by day and by night.

Generally speaking, while patterns of percentage frequency of this index differ from each other according to season and species, those by day and by night resemble to each other.

It seems that feeding activity of genus Saurida could hardly be said to vary by day and by night.

Composition of Stomach Content Items by Day and by Night

Table 4 and Fig. 5 show the compositions of stomach content items by day and by night of neighbouring days in the three localities.

In the first collection of HIUCHI-NADA, the predominant item in the diet is "Japanese anchovy" (*Engraulis japonica*), and in the second of AKI-NADA the important items are "Japanese anchovy" in occurrence and weight, and "White croaker" (*Argyrosomus argentatus*) and squids in weight, while in the third of SUŌ-NADA the predominant item is *Callionymidae*.

Some differences found in the composition by day and by night, such as absence of "Japanese anchovy" and occurrence of "Flatfish" (*Pleuronectida*) in the night collection of the third locality, could not be considered significant because of the scarcity of samples in the night collections. (Table 4)

Table 4. Percentage composition of stomach contents of *Sanrida elongata* by day and by night in the three localities
Locality 1: Eastern part of "HIUCHI-NADA", 2: Northern part of "AKI-NADA", 3: Eastern part of "SUŌ-NADA" (Fig. 1)

Food items	by occurrence						by weight					
	locality						locality					
	1		2		3		1		2		3	
	day	night	day	night	day	night	day	night	day	night	day	night
Fishes (Total)	27.8	50.0	22.9	43.7	26.9	21.8	98.7	94.5	92.0	79.4	81.3	84.5
Shrimps	0.8	—	1.3	—	0.7	6.3	1.3	—	0.4	—	0.1	2.3
Squids	—	—	2.2	8.3	2.8	—	—	—	7.5	20.3	18.7	—
Food items, belonged to fishes: *Engraulis japonica* (HOUTTUYN)	25.4	30.0	15.4	16.7	9.7	—	96.6	88.3	62.9	24.5	18.2	—
Bregmaceros japonicus TANAKA	0.8	—	—	—	—	—	0.6	—	—	—	—	—
Gobiidae	0.8	—	2.6	4.2	2.1	3.1	1.1	—	1.3	7.4	2.3	3.1
Syngnathidae	0.8	—	—	—	—	—	1.3	—	—	—	—	—
Callionymidae	—	—	2.2	—	13.8	9.4	—	—	8.9	—	58.7	43.2
Argyrosomus argentatus (HOUTTUYN)	—	—	1.3	6.3	—	—	—	—	18.1	30.2	—	—
Ammodytes personatus GIRARD	—	—	0.4	—	—	—	—	—	0.7	—	—	—
Leiognathus sp.	—	—	—	—	0.7	—	—	—	—	—	0.9	—
Pleuronectida	—	—	—	—	0.7	3.1	—	—	—	—	1.3	32.8
Fishes, unidentified	—	20.0	0.9	16.7	—	6.3	—	6.1	0.1	17.6	—	5.4
Unidentified remains	33.3	30.0	22.9	—	28.3	43.7	+	5.5	+	—	—	13.1
Empty stomach	37.3	20.0	50.7	47.9	41.4	28.1						
Number of *Saurida elongata*	125	10	222	48	139	30						
Aggregated weight of stomach contents in gr.							91.94	10.95	176.38	165.83	111.89	33.24

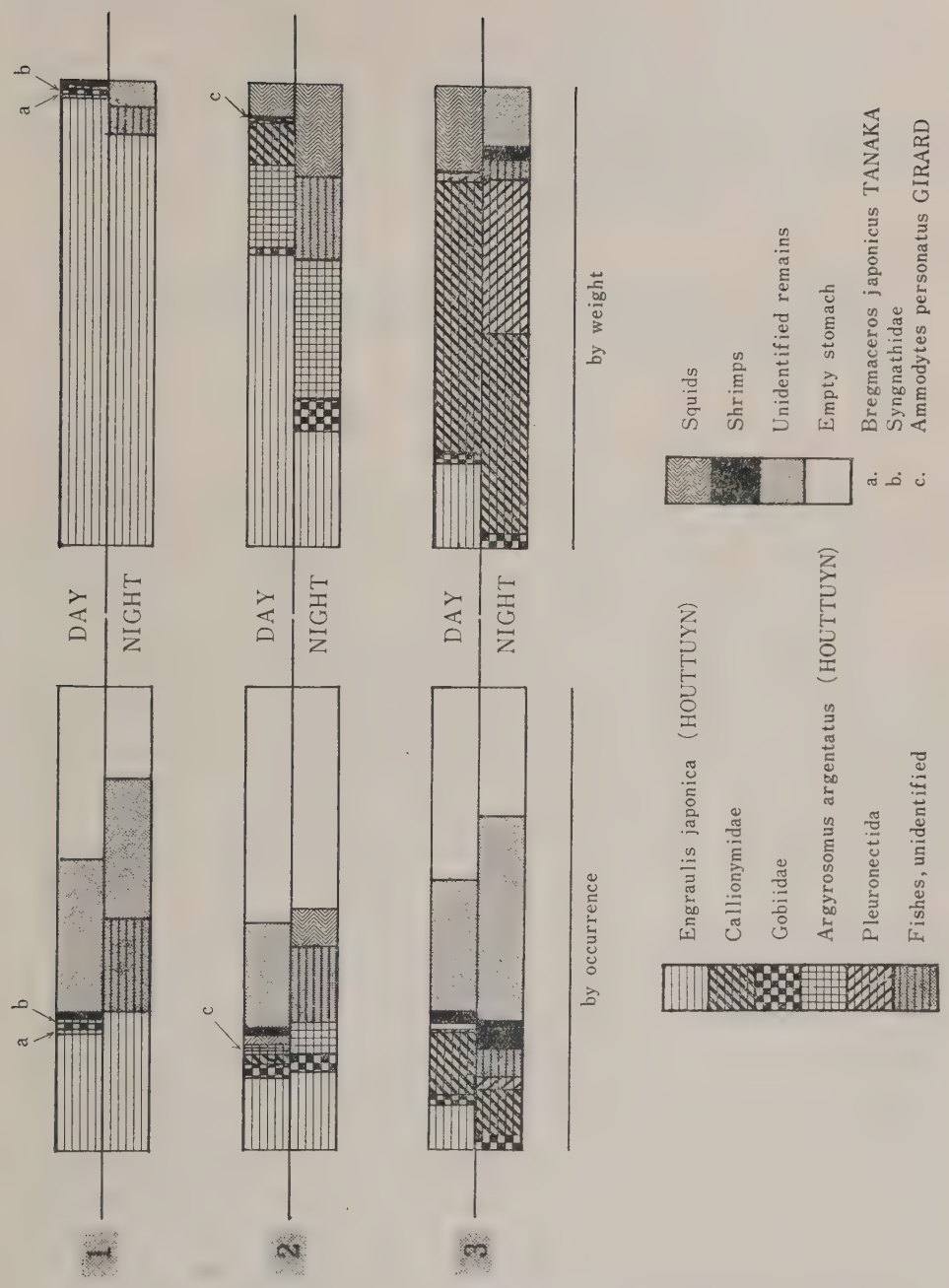


Fig. 5. Percentage frequency of stomach contents of *Saurida elongata* collected by day and by night in the neighbouring days from the three localities in Fig. 1

1: The Eastern part of HIUCHI-NADA, 2: The Northern part of AKI-NADA, 3: The Eastern part of SUÔ-NADA.

In so far as these preliminary facts are concerned, it might be suggested that genus Saurida feeds on the similar food items throughout day and night.

The intermittent but time-independent feeding activity of this dominant benthic piscivor, genus Saurida, suggested here, might be of a somewhat unexpected nature, but probable to be one type of the higher consumers in biotic community.

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Records of Oceanographic Works
in Japan (Special Number 4)
March 1960

BIOLOGY OF JAPANESE ANCHOVY, *ENGRAULIS JAPONICA* (HOUTTUYN), IN THE NANKAI REGION (II)

By

Koji Takeshita and Hiroaki Aikawa

(Fisheries Department, Faculty of Agriculture, Kyushu University)

Only a few works were reported on the maturation of the Japanese anchovy, *Engraulis japonica* (HOUTTUYN), and there remain many problems on its spawning habit.

Present authors report some basic information on the fecundity and spawning of this species. The examined specimens amounted to 250 females among 2000 individuals sampled from commercial catches mainly from the Nankai region and also from the east part of the Naikai since 1953.

Ovaries preserved in 10 percent formalin are weighed, numbers of eggs counted and egg-diameters measured by using the projector (×50) made by the Nippon Kogaku Co.. Total eggs of ovary are evenly spread in petri dish which is divided into the same eight parts. Eggs in a given part of them were counted and this treatment is repeated twice to take the mean of the both as a basic estimate. Matured eggs are ellipsoidal and their lengths of both major and minor axes are measured of eggs on some portions selected at random on the slide glass. The sections of ovary are prepared by the celloidin method and stained by the Haematoxylin-eosin. On the section of eggs, the egg-diameter through the central nucleus can be measured with less error on the minor axis than on the major axis which is variable by cutting direction.

Ratio of ovary weight to the cube of body length, as an index of maturity, changes throughout a year (Fig. 1). There are found two peaks, indicating two main spawning seasons; one is in spring, from March to May, while another in autumn, from August to September. It is also noticed from natural collection by *Asami* (1953), that two peaks exist in the occurrence of pelagic anchovy eggs in the coastal waters off east Kyushu, one in spring and another in autumn.

Based on the frequency distribution of egg-diameter, there are distinguished four types of ovary: Type A has no mode; Type B one; Type C two; and Type D three. The ovary of Type A consists of only a mass of immature eggs (stage 0), which are small, under 0.15 mm. in diameter, spherical, transparent and named cytologically the periferal nucleus stage. The ovary of Type B has a batch just separated from the immature egg-mass, with a mode between 0.25 mm. and 0.50 mm.. Eggs of this batch (stage I) are ellipsoidal, fairly opaque and

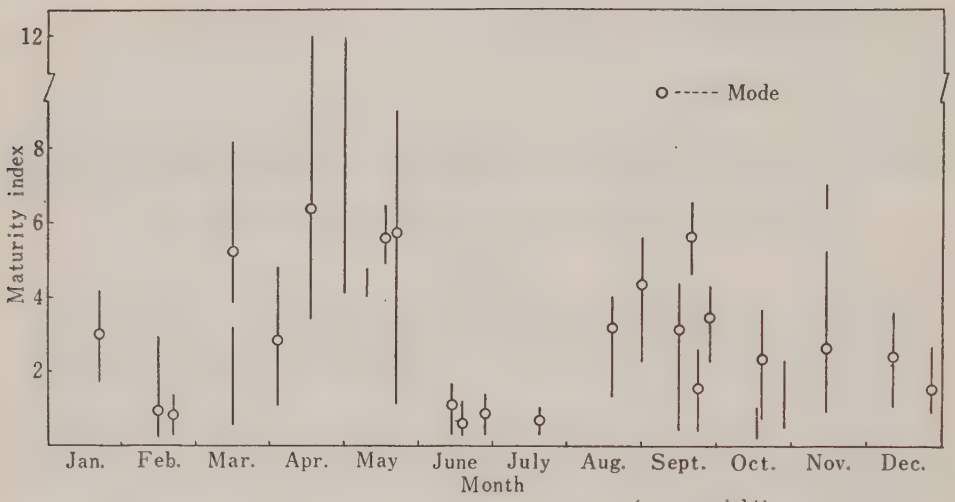

Fig. 1. Monthly changes of maturity index, $\frac{\text{(ovary weight)}}{\text{(body length)}^3} \times 10^4$

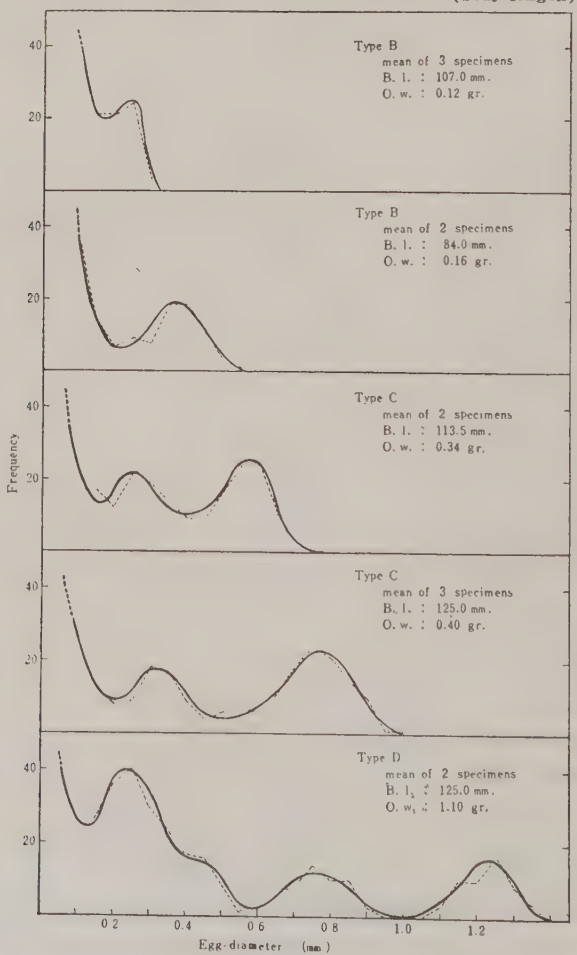

Fig. 2. Types of ovary based on the frequency distribution of egg-diameter

named cytologically the primary yolk globule stage. The ovary of Type C has two batches of egg; the first larger lies between 0.45 mm. and 0.80 mm. in diameter, comprising opaque eggs (stage II), cytologically at the secondary yolk globule stage, while the second smaller (stage I) is just separated from the immature mass. The ovary of Type D has three modes; the first largest develops over 1.00 mm. in diameter and comprises eggs of cytological prematuration stage, the third smallest batch of eggs (stage I) is now separated from the immature, in addition to the second bath (Table 1, Figs. 2 and 3). Females with the ovary of Type D are very rare. Although fully riped eggs just before spawning are hardly observable, eggs at stage III show no remarkable increase in size until spawned, since they are nearly the same in size with pelagic eggs at early stage.

Fig. 3. Photographs of the intraovarian eggs of Japanese anchovy (×50)
a: eggs of stage O–II
b: those sectioned
c: eggs of stage III
d: those sectioned

Table 1. Maturation stage of intraovarian eggs

No. of fish, examined	No. of eggs examined	Stage (Cytological division)	Diameter (mm.) minor axis	Diameter (mm.) major axis
5	250	0 (Periferal nucleus s.)	< 0.12 (< 0.12)	< 0.12
5	250	0–I (Yolk vesicle s.)	0.10 — 0.14 (0.08 — 0.18)	0.11 — 0.23
5	250	I (Primary yolk globule s.)	0.12 — 0.24 (0.14 — 0.26)	0.22 — 0.50
5	250	II (Secondary yolk globule s.)	0.22 — 0.38 (0.22 — 0.36)	0.44 — 0.84
1	50	II–III (Migrating nucleus s.)	(0.35 — 0.48)	
1	50	III (Prematuration s.)	> 0.43 (0.42 — 0.56)	> 0.96

On the relationship of the major to the minor axes of eggs, there are distinguished three different regressions during stage 0 (immature phase), during stages I and II (developmental phase) and during stage III (spawning phase), with two inflections, one is transitional stage from stage 0 to stage I, cytologically corresponding to the yolk vesicle stage and another is that from stage II to stage III, corresponding to the migrating nucleus stage (Fig. 4).

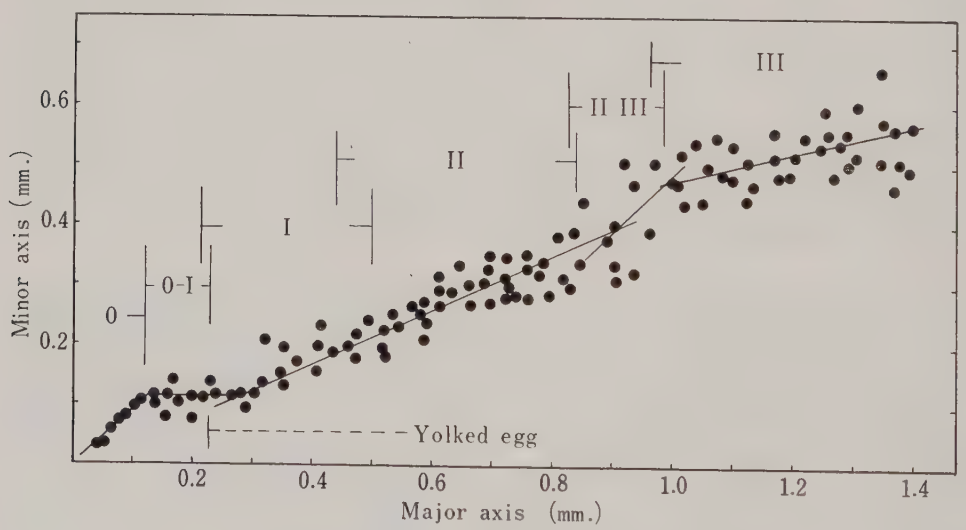

Fig. 4. Relationship of the major to the minor axes of eggs

During spawning season, almost all females under 70 mm. in body length, especially 60 mm., have the ovaries of Type A, while those between 80 mm. and 90 mm. have the ovaries of developmental phase, and in addition, ovaries tend to mature with the increase in body length (Table 2). Ovary of Type A is almost always under 0.1 gr. in weight. Weight of ovary of mature phase is above 0.1 to 1.1 gr., 0.45 gr. on an average.

Table 2. Frequency of ovary type in spawning season

Size group (mm.)	Type A		Type B		Type C (D)	
	n	%	n	%	n	%
80– 90	20	68.7	8	27.6	1	3.4
90–100	16	27.1	33	55.9	10	16.9
100–110	6	8.6	45	64.3	19	27.1
110–120	2	11.1	9	50.0	7	38.9
120–					4 (2)	100.0
Total	44	24.2	95	52.2	41 (2)	23.6

Total number of yolked eggs increases with body length and also the number of mode, while the number of yolked eggs of the first batch remains nearly constant through ovaries of all types, irrespective of number of modes, within the range between 2000 and 6000, about 3500 on an average (Table 3). This suggests that there is neither addition to nor subtraction from each batch during its development and each batch of riped eggs may be spawned at a time. Spawning of this species is multiple and presumably at least three times in one season.

Table 3. Estimates of ovaries

No. of specimens	Size group (mm.)	Weight of ovary		Total No. of yolked eggs		No. of eggs of the first batch	
		Range	Mean	Range	Mean	Range	Mean
	Type B (one-mode)						
1	70– 80		0.10		4808		2780
8	80– 90	0.07–0.37	0.26	2400– 6968	4655	1670–4720	3616
33	90–100	0.07–0.48	0.32	2488–10672	4893	1110–8190	3532
45	100–110	0.07–0.65	0.39	1024–10944	5402	1201–6550	3534
9	110–120	0.18–0.70	0.50	4904– 6664	5789	2080–4510	3637
	Type C (two-modes)						
1	80– 90		0.17		2368		1468
10	90–100	0.23–0.38	0.32	2482– 9896	5260	1560–3580	2644
19	100–110	0.22–0.53	0.38	2992–12768	6155	1620–8880	3672
7	110–120	0.17–0.55	0.35	5152– 7456	6458	1540–5220	3547
1	120–130		0.55		8768		4170
3	130–140	0.17–0.75	0.55	6505–12950	9673	2350–5890	3560
	Type D (three-modes)						
2	120–130	0.50–1.70	1.10	12100–16740	14420	3100–5200	4150

Considering from the differences in the number of vertebral bones and also in the size of the first age-mark on scale, the present authors could distinguish two seasonal spawning groups, one in spring and another in autumn. Broods produced in any season certainly become matured at nearly 100 mm. in body length on an average, about a year after spawned, though they range 70 mm. to 140 mm. due to such causes as (1) long duration of spawning season, (2) multiple spawning and (3) individual variation itself in growth.

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March 1960

STUDY ON THE NATURAL RADIOACTIVITY OF BOTTOM DEPOSITS (II)

By
Hiroshi Niino
(Tokyo University of Fisheries)

Bottom Deposits in the Vicinity of Takamatsu City, Seto Inland Sea

Introduction

Several islands are scattered around Takamatsu City in the eastern part of the Seto Inland Sea, and where the bedrock consists of granite. It is locally covered by younger volcanic rocks, agglomerate and tuff. According to the Geological Survey of Japan, some of the stations on the sea bottom near Takamatsu City revealed that the deposits are high in natural radioactivity. In 1958 sampling was made at twenty-five stations in the area between Takamatsu City and Tsuda Bay passing through Shido Bay. As the surveyed area is under the influence of strong currents, the sampled deposits were mostly coarse-grained materials such as gravel and coarse sand, whereas muddy samples were few.

Submarine Topography and Bottom Deposits

The submarine topography of the surveyed area is extremely intricate owing to the occurrence of islets and banks. The sampling localities lie at about 2 km from the coast and at the depths of 20 m to 50 m. Sampling was conducted by the Shinyo-maru, training ship of the Tokyo University of Fisheries, using the Niino-type dredger. The samples thus collected were placed in cotton bags, dried, and preserved.

Natural Radioactivity of Bottom Deposits

The samples were passed through the Tyler sieves, by which the grains ranging in size between 8 mesh (2.362 mm) and 14 mesh (1.68 mm) were obtained. Then the natural radioactivity per ten minutes of 100 gr of such grains from each sample was measured by the Geiger counter manufactured by the Kobe Kogyo Co. The obtained values were compared with those of natural radioactivity in the hinterland. From the result it has become known that the natural radioactivity at stations 14 and 24 (more than 30%), 2, 4, 10 and 25 (more than 15%) and 13 and 16 (more than 10%) is higher than that in

the hinterland. The bottom deposits having high radioactivity generally consisted of poorly sorted coarse sand.

Shells

The shells contained in the above-mentioned deposits had characteristics of inland sea inhabitants.

Bottom Deposits in the Vicinity of Miyako, Iwate Prefecture

Bottom deposits were sampled at thirteen stations off the coasts of Ogi and Raka north of Miyako Harbor, Iwate Prefecture. The study on these samples is still under way.

Locations of investigation in the vicinity of Takamatsu City

Table 1. Locations of bottom deposits investigation in the vicinity of Takamatsu City

A: Abundant S: Scarce

Location	N. L.	E. L.	Water depth	Bottom deposits							Radioactivity count/10 minutes
				Rock fragment	Gravel		Sand		Mud	Organism	
					Large	Small	Coarse	Fine			
1	34°20′.3 N	134°16′.5 E	35 m			A		A		S	9
2	20.4	16.2	27			A				S	30
3	20.7	15.7	37			A		A		S	7
4	22.1	14.9	40			A		A		A	30
5	21.1	14.1	37			S	S			S	9
6	21.4	13.7	20				S	S	A		15
7	21.8	13.2	17			—				—	—
8	22.3	12.8	36	A							—
9	22.6	12.2	28			A	S			A	9
10	22.7	12.0	27			A	A	A		S	31
11	23.0	11.6	20			S	S	A		S	0
12	23.7	11.0	30			S	S	A			2
13	24.15	10.2	32			S	A	A		S	28
14	24.2	09.6	20				S	A			6
15	23.8	09.2	47			A	A	A		S	9
16	23.4	09.8	57			A	A			A	27
17	22.7	10.4	30			A	A	S		S	16
18	22.6	11.0	18			S	A			A	12
19	25.2	18.3	40		A		A			S	14
20	25.4	17.7	47			A	S			S	3
21	25.6	06.8	18			A	S	A		A	7
22	25.55	05.8	26				S	S	A	S	15
23	25.3	04.7	23				S	A	A		75
24	24.5	04.7	39		A		S			A	1
25	24.4	04.7	17				S	A	A	S	—

Table 2.

Locations of bottom deposits investigation north of Miyako, Iwate Prefecture

A: Abundant

Location	N. L.	E. L.	Water depth	Bottom deposits			
				Rock frag.	Gravel	Coarse	Fine
1	39°55′.8 N	141°58′.2 E	37m				A
1′	55.7	58.1	37				A
2	55.1	57.9	38				A
2′	55.1	57.8	38	A			
3	54.2	58.2	48				A
4	50.6	59.7	50				A
5	50.7	59.5	48				A
6	49.8	142°00.2	62		A	A	
7	49.6	〃 00.3	64				A
8	55.7	141°57.9	33				A
9	55.9	〃 57.7	30				A
10	55.9	〃 57.3	24				A
11	55.1	〃 57.6	32				A

Table 3-a. Shells from investigated bottom localities near Takamatsu City

Species & individual number \ No. of sampled station	1	2	3	4	5	6	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Leucotina gigantea Dkr.	1				(1)																		
Amathina tricarinata (L.)										1													
Syphopatella walshi (Rve.)															1								
Natica severa (Gould)							△1																
Bedevina birileffi Lis.					1									3									
Clavus (*Brachytoma*) *tuberosa* (Smith)							1																
Dentalium buccinulum Gould										2													
Arca ocellata Reeve										1													
Nipponarca bistrigata (Dkr.)					1	△1	1			3				1							1		
Striarca tenebrica (Rve.)	6	3	3		3	1	1	3	3	15	2	1	1	1	1	2		2	3		1	3	1
S. oyamai Habe				2	(1)		1		1	6			1	2	1				3		1		
Volsella nitida (Rve.)																	△1						
V. nipponica Oyama					1																		
V. compta (Sow.)																1							
Atrina japonica (Rve.)	△1	(1)									△1		(1)					△1					
Pecten albicans (Schr.)					1																		
Chlamys pelseneeri D. & B.	1	1		1	1		△1	△11	3	3				2					1		1	1	
Volachlamys hirasei (Pils.)		1								4	2				1		△1	1	△1				
Promantellum orientale (A. et R.)			1	△1	2		2			2					3	17	△1	1		1	△2	1	△1
Anomia lischkei D. et F.					3		(1)			3		1			3	1			2			2	1
Monia radiata (Sow.)											1		1	2			1						
Ostrea denselamellosa Lis.	1		△2					1															
Crassatellites nanus (A. et R.)	9	7	3	15	4	4	14	21	1	2	2		2	7	17	1	4	9	6	3	3	6	1
Cardita leana Dkr.				3						3				2					2				
Anisodonta gouldi A. Ad.	2	1	1		2	2		2	2	4	3							2	2			5	
Ctena delicatala (Pils.)				1																			
Joannisiella cumingi (Hanley)			1							3					1				1			5	

Table 3-b. Shells from investigated bottom localities near Takamatsu City

Species & individual number \ No. of sampled station	1	2	3	4	5	6	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Nesobornia nipponica (Yok.)										2	1	1							1				
Fluvia mutica (Rve.)				(1)																			
Circe stutzeri (Donovan)					1				1														
Pitar affinis (Cmel)										1	2					1			△1				
Callista chinensis (Holten)																1							
Venerupis variegata (Sow.)																1		2	2				
Paphia versicosa (Gould)	2		3					1	△3				1	1	3	1	△2	1					
Protothaca jedoensis (Lis.)		1								4	1		4	6	1			1	3		△1		
Placamen tiara (Dillwyn)	2	1							1	3							1						
Dosinia sericea (Rve.)																1							
Raeta pellicula Rve.																			1				
Mactra sulcataria Rve.										2	1	4							1				
Oxyperas bernardi (Pils.)			1				1			△2			1	△2		3	△2		1				
Lutraria arcuata Rve.			9																				
Schizothaerus keenae K. et H.	(1)		9								2	1				1							
Semela zebuensis (Hanley)				2												1							
Gari maculosa (Lam.)				△1																			
Cadella narutoensis Habe, M. S.										6		3		1					1				1
Abra kanamarui Kuroda		2				3		1	(1)	3	5	3	(1)			1	(1)				1	2	
Arcopagia subtruncata (Hanley)									1	1													
Solen gordonis Yok.				△2			△2	2		2	△1		△1	△1	△1	△5			6				
S. roseomaculatus Pils.	1	1	1	1		△2		△1		3	△3	△2			△1	1		(1)	1		△1		
Hiatella orientalis (Yok.)	(1)													1									
Varicorbula yokoyamai Habe												3							1				
Solidicorbula erithrodon (Lam.)										1	1							1	(1)				
Anisocorbula venusta (Gould)	(2)	4	1	3	2	5	5	4	1	1		1	1	2	2	2	1	1	1		2	1	

Remark: △ Fragment
( ) Conjoined valves

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EVIDENCE FOR RECENT CHANGES IN SEA-LEVEL OF THE ATSUMI PENINSULA, ATSUMI-GUN, AICHI PREFECTURE

By

Kotora Hatai* and Shozo Hayasaka* and Takehiko Iwai**

(* Tohoku University: ** Hirosaki University)

Introduction and Acknowledgements

The Atsumi Peninsula which extends westwards in narrow finger-like form from the mainland with Lake Hamanako on its eastern foot and Toyohashi City on its western, is characterized with the smooth coast-line of its southern coast without notable indentations and by the more or less abrupt interruption only near Akabane mura. Immediately southeast of Oishi and between Otto and Doda, both in Akabane-mura, Atsumi-gun, there are exposed impure limestone, clayslate and chert, which belong the Paleozoic sedimentaries developed in the Peninsula as high hills. These Paleozoic rocks are exposed along the coast at the said localities and also near the tip of the Peninsula, that is to say, near Cape Irakomisaki. However, these rocks in the form of blocks strewn along the coast preserve interesting morphological features which are evidence of recent change in sea-level during a young geological age.

The smooth coast line of the southern side of the Atsumi Peninsula suggests emergence topogaphy, but whether such general features are due to upbuilding of the extensive sand beach upon a stable foundation, or to geologically recent changes in sea-level related with emergence, or to outbuilding of eroded young formations upon a submerging or stable foundation, requires evidence. The descriptions and interpretations of the structures regarded as evidence for the mentioned phenomenon are the purpose of the present article.

Here deep appreciation is expressed to Japan Society for the Promotion of Science for making the necessary arrangements for field and laboratory works.

The Sea-coast near Oishi, Akabane-mura, Atsumi-gun

The sea coast southeast of Oishi, Akabane-mura, Atsumi-gun, Aichi Prefecture, makes an abrupt, morphologically outstanding break in the rather smooth coast-line extending from Cape Irakomisaki in the west to Lake Hamanako in the east. This sharp break in the coastal morphology is due to the development of impure limestone, clayslate and chert of Paleozoic age at the place. These Paleozoic rocks make the 170–180 meter high hill immediately north of the coast, and it is inferred that the old rocks exposed on the beach are in extension of those

building the high hills. Therefore, it is thought that the geologically young sedimentaries developed in the intervening area and unconformably covering the Paleozoic rocks, make but a thin covering of some 15 meters. Thus, interpretations indicate that the Paleozoic rocks exposed on the beach may have been part of a promontory, remnants of an extensive abrasion platform, or have been an island during an early stage in the deposition of the young sedimentaries which cover them.

Aside from the Paleozoic rocks which are now exposed on the beach as isolated blocks measuring, in most cases, up to about ten meters in length and less in width, situated close together or separated from one another by various distances, but with their top surfaces at about the same height above sea-level, the sea coast is provided with either a sand beach, sand and gravel beach, or one predominantly of gravel, according to locality and nature of the sea-cliffs, at whose foot they are developed. The beaches do not have the same inclination everywhere, but may vary according to width, the presence or absence of obstructions, the presence or absence of drainage from the land, material building them and to the sediments building the sea-cliffs at the locality.

Structures Observed in the Paleozoic Rocks

Among the structures observed in the Paleozoic rocks exposed along the sea-coast southeast of Oishi and between Otto and Doda, Akabane-mura, to be mentioned are wave-cut notches at different heights above sea-level (Plates 2, 3, 5 and 6), small holes made by boring shells now high above sea-level (Plate 9), uplifted wave-cut crevices (Plate 7), probable uplifted sea-cliff (Plate 10) and either benches or platforms partially destroyed by agencies subsequent to their formation (Plates 1, 3 and 7). Structures now in the stage of development (Plate 8) and comparable with the uplifted crevices (Plate 7) are found in the process of formation along the beach (Plate 8). Details of these structures and their interpretations are as follows.

Wave-cut Notches

The sharp bow-shaped convexities observed in the Paleozoic cherts and impure limestones of the sea coast southeast of Oishi and between Otto and Doda, are all characterized by having smooth surfaces which appear more or less polished. These occur at the foot (Plates 3 and 6) and middle part (Plate 5) and may be singular or double (Plate 2); these are incised in the Palaeozoic rocks. They are better developed in the cherts than in the limestones, because although more easily incised in the latter kind of rocks they would also be more easily destroyed. Smooth surfaces which appear to be more or less polished are phenomena well exhibited on wave-cut notches incised in rocks such as schist, quartz-porphyry, conglomerate and even in those of siltstone along the present coasts of the Shima Peninsula in Mie Prefecture, Tanabe Bay and in the vicinity of Wakayama Prefecture, and the Boso Peninsula in Chiba Prefecture. Since

such wave-cut notches are developed at or near sea-level, their presence about at two meters above the present sea-level indicates that a change has taken place.

Borings of Pelecypods

In a clayslate of the Paleozoic deposits exposed on the sea coast between Otto and Doda near the townships of Akabane and Irakomisaki, there were observed numerous circular holes measuring about one to two centimeters in diameter and about three to five centimeters in depth. Although the fine sculpture found in bore-holes of Recent Pholadidae pelecypods could not be recognized in any of the observed holes, it is inferred that they are the result of such bivalves. These holes are not thought to be a result of sand-blasting by which honey-comb structures develop, because of their uniform diameters and depths. Another datum upholding such a view is that the diameters of the holes increase with depth and the sides are smooth instead of rough as in the case of holes produced by sand-blasting. Also such holes in clayslate were found at only one locality, therefore, if they are due to sand-blasting they should be found at other localities and with varied diameters and depths provided with rough inner surface and with their outer surfaces frequently with the development of case-hardening. These pelecypod bore-holes occur at about three and a half meters above present sea-level.

Uplifted Wave-cut Crevices

The inferred uplifted wave-cut crevices (Plate 7) were found in the Paleozoic chert exposed on the sea coast between Otto and Doda above mentioned. Here among three large blocks of chert, each measuring about ten to less meters in length and about three to five meters in width, there were observed crevices by which they are now separated into three portions. These crevices measure about three to five meters in length, 50 to 70 centimeters in width and about two meters in depth. Their walls are nearly vertical, but with irregularities in both vertical and longitudinal directions. Sometimes incipient wave-cut notches are developed at their bases partially covered with beach sand. With irregularities in both vertical and longitudinal directions as mentioned above, they show smooth surface with slightly polished aspect.

These crevices are thought to be comparable with those now in the process of development on the same sea-coast. It is thought that, from observations along the sea coasts of Wakayama, Mie, Aichi, Shizuoka, Chiba and Miyagi Prefectures, the continued emergence and relative down-cutting by wave erosion suffice for their development. Even along present coasts, crevices due to or enlarged by wave erosion generally along faults, fissures, clastic dikes, joints and cleavage planes are not rare. Various degrees in development can be observed along present sea-coasts, even though the amount of change in sea-level may not be great. From such reasons and previous observations on recent examples, it is considered that these uplifted crevices not only indicate

a change in sea-level but also serve as evidence for vigorous wave-erosion at the time of their construction.

Probable Uplifted Sea-cliff

The probable uplifted sea-cliff (Plate 10) developed in Paleozoic chert was observed along the sea coast near Oishi already referred to. Here on the sea-ward side of a large mass of chert measuring about three meters in height and about seven meters along its front, there was observed a slightly convex vertical surface. This face of the chert mass shows evidence of having been smoothed by some agency and is slightly polished. The foot of this face is sigmoidal with convexities of about 15 to 14 centimeters, and also more or less polished and smoothed. This smooth and more or less polished face-surface of the chert may be a product of wind erosion, but the slightly convex face in vertical section must be due to some other cause. Since the chert-face is directed towards the open-sea and such convexities are common phenomena of wave erosion it is assumed that it represents a sea-cliff with its foot now about one to one meter and a half above present sea-level.

Uplifted Benches or Platforms

The examples referred to the probable uplifted benches or platforms (Plates 1, 3 and 7) were observed on the sea coast between Otto and Doda mentioned in earlier lines. Although along the sea-coast there could be seen numerous isolated impure limestones, clayslate and cherty rocks in the form of rectangular, rounded or of irregular shape and preserving such morphological characteristics as already described, it is problematical whether they were originally a continuous mass, blocks detached by faults, merely fallen down blocks of the Paleozoic terrain detached by subsequent weathering, erosion, or landsliding, or eroded remnants of an originally continuous or partially continuous mass. This is difficult to determine, but it may be advanced that since the top-surfaces of the isolated Paleozoic rocks now exposed along the sea coast measure about three and a half to four meters in heights above present sea-level they are considered to not represent, at least the larger ones, fallen blocks of the Paleozoic terrain, particularly because their orientation is not at random. Also since the heights of the wave-cut notches occupy similar positions, it is inferred that this evidence shows that their positions are not at random. From the occurrence of uplifted crevices and their morphology, it seems very probable that they were developed along some pre-existing structure such as faults, clastic dikes and others. If this is actually the case, then from the directions of the crevices, it can be postulated that faults may have been the governing factor. Upholding this view is the brecciated nature of the impure limestone and of the cherty rocks. Thus, it may be probable that the now isolated masses of rocks are continuous vertically with the Paleozoic foundation, but isolated due to shearing and faulting. Accordingly, their gouge, fault clay or fault breccia would be subjected to the erosive agencies more readily than other parts of the same rock. By this process the brecciated or gouge parts were eroded away by subsequent forces to produce

the isolated arrangement of the Paleozoic rocks now distributed along the sea coasts of the above mentioned localities. The top surfaces of these tectonically detached rock masses occupy nearly the same level, and thus it may be inferred that this fact may also be evidence in favor of the view that the rocks are vertically continuous with the Paleozoic foundation and do not represent detached blocks of random orientation.

Whether the top-surfaces of the isolated masses can be considered to have represented an abrasion platform or independent benches is a problem yet unsolved. However, if it is thought that prior to erosion of the tectonically produced brecciated sediments between the now isolated rock masses there was developed a platform, and that subsequent erosion agencies removed the crushed material after development or during the process of formation of the platform, then it follows that the surfaces of the isolated masses were formed originally as a platform. But, if removal of the crushed materials was expedient over that of platform planation, then it may be that independent benches were formed. This problem is reserved for another opportunity because more examples should be studied.

Covering of the Paleozoic Rocks

The Paleozoic rocks whose morphological features have been described above are unconformably overlaid (Plates 2 and 4) with sediments consisting of granule conglomerate admixed with pebbles and sandstone (Plate 4), or of conglomerate (Plate 2). These covering sediments have been considered to be of Pleistocene age by Oinomikado (1933) and Kuroda (1958), but to what part of the Pleistocene they belong is a problem to be settled by future study. One of the writers (S. Hayasaka) is now working on the molluscan fossils and stratigraphy of the Peninsula and the results are expected to be made before long. In Plate 2, where there are developed double notches, the conglomerate abuts against the Paleozoic chert, and in Plate 4, the granule conglomerate admixed with pebbles and sandstone abuts against chert. Although not shown in the annexed illustrations, the clayslate with pelecypod bore-holes is unconformably overlaid with conglomerate. Therefore, it is evident that the above described morphological features were produced before the deposition of the covering Pleistocene sediments, and that their structures were preserved by those sediments.

Significance of the Described Structures

From the present positions of the morphological structures with regard to present day sea-level, described in this article, it is evident that considerable changes in sea-level had taken place since their development. After the formation of the flat surfaces represented by the independent rock masses, there was an uplife of land shown by the wave-cut notches, equal to at least three and a half to four meters, after which there occurred a period of submergence which resulted in the deposition of the marine Pleistocene sediments which amount to at least 15 meters in thickness in the vicinity of Oishi, but less at Otto and

Doda. After deposition of these sediments there again occurred a gradual uplift and relative lowering of the sea-level amounting to at least 15 meters.

The tilting of the Atsumi Peninsula northwards seems to be related with the development of narrow abrasion platforms now situated above present sea-level, the wave-cut notches a little above high tide on the sea-ward side of several islets below Oishi and between Otto and Doda. That the morphological features of the northern shore-line of the Atsumi Peninsula differ from those of the southern coast, that drainage is towards the southern side, and that the topography is higher on the southern than along the northern coasts, all point to tilting of the Peninsula in a very young geological age. Further discussions in this concern will be reserved for another opportunity.

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Explanation of Plates

Plate 1—Mass of chert exposing penecontemporaneous deformation. A small wave-cut notch is seen in the upper right hand part. Locality: Between Otto and Doda, Akabane-mura, Atsumi-gun.

Plate 2—Double wave-cut notch in chert. Pleistocene conglomerate abuts against this double notch. Locality: Between Otto and Doda, Akabane-mura, Atsumi-gun.

Plates 3, 5 and 6—Wave-cut notches in limestone and chert. Locality: Between Otto and Doda, Akabane-mura, Atsumi-gun.

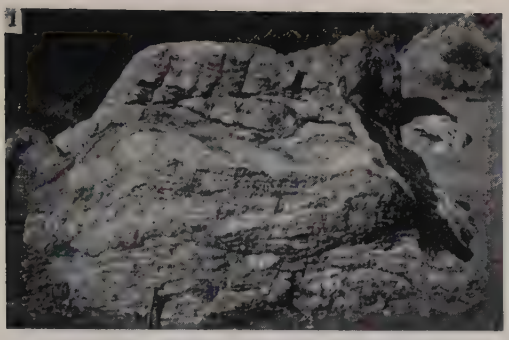
Plate 4—Granule conglomerate admixed with pebbles and sandstone agutting against Paleozoic chert at whose base is incised an incipient notch. Locality: Between Otto and Doda, Akabane-mura, Atsumi-gun.

Plate 7—Uplifted crevice seen from above. Incised in Paleozoic chert. Locality: Between Otto and Doda, Akabane-mura, Atsumi-gun.

Plate 8—Crevices in the process of development in Palaeozoic impure limestone of the sea coast southeast of Oishi, Akabane-mura, Atsumi-gun.

Plate 9—Paleozoic clayslate with pelecypod bore-holes exposed on the sea coast between Otto and Doda, Akabane-mura, Atsumi-gun.

Plate 10—Probable uplifted sea-cliff on the sea coast southeast of Oishi, Akabane-mura, Atsumi-gun.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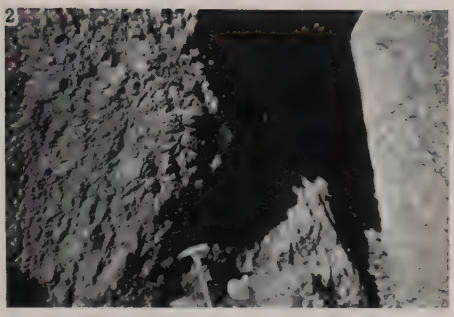
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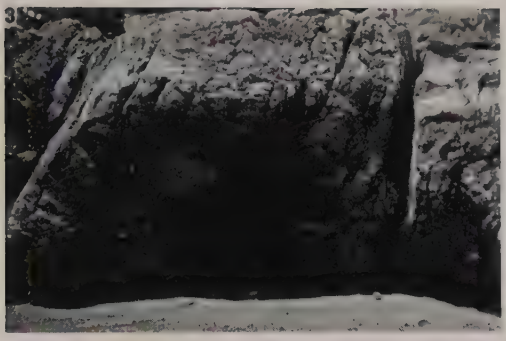
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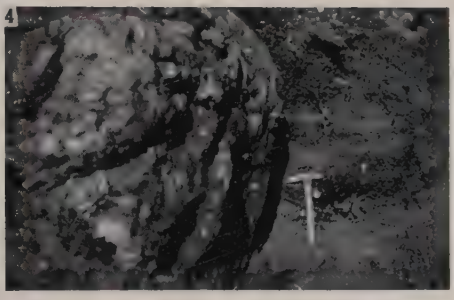
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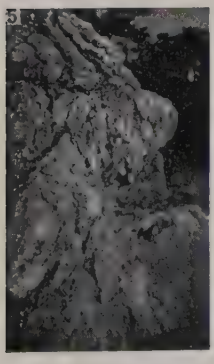
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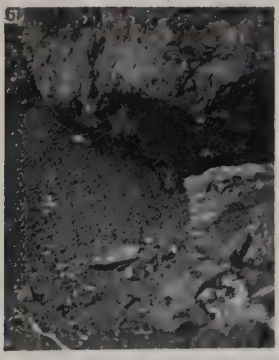
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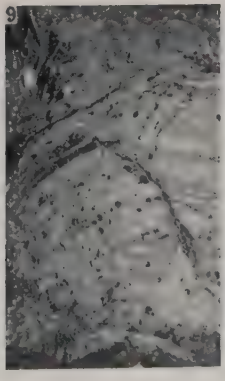
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GROUND WATER AND RELATED PHENOMENA OBSERVED ALONG THE SOUTHERN COAST OF THE ATSUMI PENINSULA, AICHI PREFECTURE

By
Kotora Hatai*
Shozo Hayasaka* and Takehiko Iwai**
(* Tohoku University: ** Hirosaki University)

Introduction and Acknowledgements

During observations along the southern sea-coast of the Atsumi Peninsula, Aichi Prefecture in the summer of 1957 and January 1959, the writers were fortunate in finding some phenomena which are related with ground water. These phenomena will be described in this article.

Here the writers express their cordial thanks to the Japan Society for the Promotion of Science for making the necessary arrangements for field and laboratory works. Thanks are also expressed to Professor Eigo Sakai of the Aichi Gakugei University in Okazaki City, Aichi Prefecture and Professor Gunjiro Sakai of the Hirosaki University in Hirosaki City, Aomori Prefecture, for their encouragement in many ways.

The Southern Coast of the Atsumi Peninsula

The southern coast of Atsumi Peninsula, Atsumi-gun, Aichi Prefecture, exhibits well developed sea-cliffs and some false-cliffs extending from near the tip, or from Irakomisaki in the west to near the Hamanako Lake in the east. Although the sediments exposed in the said cliffs show variation in lateral extent and vertical sequence, it may be said that sands, gravels and silts are the dominating lithological facies. The sediments are inclined towards the north in general, and their trends are almost parallel with the sea-coast. The geological structure of these young sediments is rather simple because no large faults or related tectonic phenomena are developed, but when observed in detail, abundant complex structures can be observed. The complex structures comprise a variety of forms, such as cross-laminations, wash-outs, pull-aparts, soft-rock pebbles, slumping, and other kinds of sedimentary structures (Hatai and Hayasaka, 1958). Descriptions of these structures, major and minor are expected to be published at another opportunity.

Ground Water and Produced Structures

As already mentioned the Pleistocene sediments of the Atsumi Peninsula are inclined northwards at angles of about four degrees. The exposed lowest sediments consist of silt or sandy silt in which fossil molluscs are widespread. Above these silts are superposed sands and gravels as independent beds or admixed. Such sediments are favorable for the accumulation of water, there being thick porous deposits above and impervious ones below. From the dip of the strata it would appear that the ground water should migrate northwards or northwestwards according to the inclination. However, along the sea coast there are found numerous places where the ground water seeps out, and in many cases it actually forms a stream (Plate 2) and water falls of different magnitude. Such a phenomenon of the accumulated ground water draining in a direction opposing the general inclination of the sediments may be explained in the following way.

The increased accumulation of ground water gradually rises the water table, which must overflow its dam; in this case the southern dam of the ground water is the silty sediments developed below the porous media and inclined northwards or northwestwards. The overflow of the ground water causes seeping out between the pervious and impervious sediments, and where the conditions are favorable and the contained amount of ground water is great, the quantity and velocity of outflow must be increased to form a stream or water-fall.

It is thought that underground water streams may develop to produce passages in funnel or tunnel shape. When such passages are once developed the surrounding water will drain into them to further assist in the enlargement and importance of them. When such ground water overflow their dam, small water-falls and streams will be produced, as can be at several places along the southern coast of the Peninsula.

Tunnels (Plates 3, 6 and 7) produced as a result of underground drainage of water are found along the southern coast of the Peninsula. One developed in conglomerate measured about 50 centimeters in diameter and more than five meters in length, and because being extended landward into the conglomerate bed and slightly inclined upwards, its exact length could not be measured. The tunnel is more or less irregular in shape in the conglomerate, but its walls are smooth and coated with thin limonite, which was precipitated by the ground water. Such tunnel (Plate 3–two tunnels, Plate 6–two holes, Plate 7–two holes) may have circular, subcircular or more or less oval orifices, and may differ according to the kind of sediments in which they develop. However, they are characteristic in having smooth walls due probably to abrasion or corrosion of the transported materials and to the water itself, and generally have thin coating of limonite on their walls as a result of precipitation from the subterranean waters.

From the observations it is considered that ground water may not flow in sheet-form, but in branch-shape, tunnel-shape or some other way. Similar structures have been described by Hatai and Iwai (1960) from the Miocene sediments in Wakayama Prefecture. Thus, it seems clear that ground water makes passages of some kind during its migration or flow by gravity along some inclined subsurface.

When ground water seeps out between the pervious and impervious sediments several kinds of structures often develop, and since there has been described very little concerning them, it is thought worthy to make mention of some of those observed along the southern sea coast of the Atsumi Peninsula. Some of these structures consist of water-falls, under-mining, various erosion features, depositional structures and others.

After under-mining by the spring water has developed the water will, according to the quantity and velocity of supply, flow over the constructed ledge to flow along its under-surface then down along the underlying sediments. During this process it will not only erode that part but will also transport sediments at the same time. Parts of the transported sediments will be subjected to deposition at positions according to the inclination and nature of the underlying sediments over which the transportation takes place. By this process there sometimes develop sand stalagmites (Plates 1 and 5), which may possess very acute to rather broad angle. Rarely erosion by dripping water and deposition by the flowing water will produce structures closely similar to vertical sand-pipes when seen from a distance (Plate 5, the hollows represent places where the dripping water fell).

When spring water flows through to be expelled from a horizon above that of the impervious silt, it will tend to transport the fine grained sand down over the face of the silt where deposition will occur. By this process there are sometimes found on the faces of silt beds, stalagmitic vertical pillars of sand (Plate 8). These deposited pillars may be again destroyed by the erosive forces of the trickling or flowing down waters which produced them. Thus, there seems to be a cycle of erosion and deposition. Immediate run-off also tends to make badland topography, (Plate 4) and water issued from different horizons of the sand also tends to produce similar features.

Dripping water falling into sand or into silt may produce different structures which can be preserved by the filling of foreign sediments as of sand in silt, or of silt in sand. The development of vertical holes with irregular walls may be developed by water dripping into sand, and thus produce a pipe-like structure. The developed pipe may be preserved in the geological column, and if so, it may be distinguished by the not very large diameter, irregular walls, narrowly rounded bottom and poor sorting of the contained sediments. Incomplete structures of this kind have been observed at a few places along the southern coast of the Peninsula. When the amount of flow is great and the height of fall from ten to several ten centimeters, the receiving sediment of silt

there may develop irregular gullies, holes more or less resembling minor plunge-holes, pot-hole like excavations, troughs, trenches and sometimes also branched minor valley systems. With continued water supply these structures will grow with the retreat of the cliff or of its developing a vertical trough-like structure. Should the water supply fail and the above mentioned structures be filled-in with sand or silt it is certain that interesting structures will be the result. However, although the process in production of the said structures could be observed in the field, their filled-in aspect was observed only in a few examples. When filled-in the examples are sectioned by a pocket-knife and it was noticed that their upper surfaces were nearly flat while the filled-in portions retained the shape of their mould.

Geological Significance

Since there is a great probability of the above mentioned structures being preserved under favorable conditions, it is also possible that such may be found in the geological column, or may have been found and published with explanations diverging from their actual process in development. For example it seems that sand-pipes in horizontal position (parallel with the bedding plane), may be attributed to the action of worms, trails of animals or to decayed water-logged branches or trees being dragged along the bottom. However, as described elsewhere (Hatai and Iwai, 1960), such kinds of sand-pipes may be produced by ground water.

Should the tunnel-like structures described in earlier pages, which are the result of ground water, be filled-in and preserved in the geological column, their origin may be attributed to log-concretions and to other phenomena, and many of the other observed present day phenomena already mentioned above may be assigned to causes far from the true one.

For the reasons that the observed features may be preserved in the geological column, the writers feel that our knowledge concerning recent phenomena should be given more attention to understand more fully the various problematica occurring in the geological column. Because it is by this method that we may more fully interpret the history preserved in the rocks, the writers expect to extend their observations on recent phenomena.

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Explanations of Plates

Plate 1–Sand stalagmites developed under a ledge of Pleistocene siltstone. Formed by water transporting sand and by water eroding the sand. Locality: Sea coast of Akabane-mura, Atsumi-gun, Atsumi Peninsula.

Plate 2–Ground water overflowing the dam of inclined siltstone, forming a stream and water-fall below which there are found various structures as trenches, gullies, troughs, etc. Locality: Sea coast of Takatsuka, Toyohashi City, Aichi Prefecture.

Plate 3–Two holes in Pleistocene conglomeratic sandstone overlying siltstone. These two holes are due to ground water. Locality: Sea coast of Tonami, Toyohashi City, Aichi Prefecture.

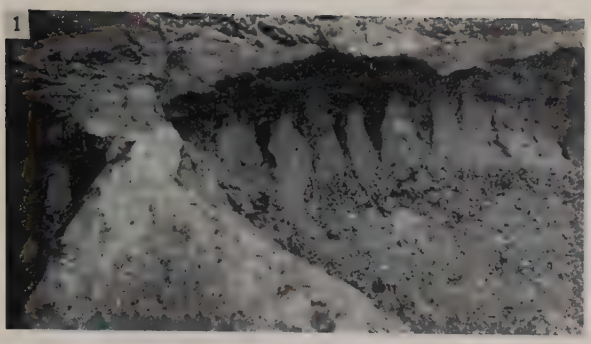
Plate 4–Minor badland topography due to expelled ground water. Locality: Sea coast of Akabane-mura, Atsumi-gun, Atsumi Peninsula.

Plate 5–Vertical pseudo-sand-pipes or narrow stalagmites and vertical perforations of dripping water under a ledge of sandy siltstone. Locality: Sea coast of Akabane-mura, Atsumi-gun, Atsumi Peninsula.

Plate 6–Two holes made by ground water, the lowest dark patch is not a hole. Locality: Sea coast of Tonami, Toyohashi City, Aichi Prefecture.

Plate 7–Two holes in loose conglomerate in the cliff of the Pleistocene deposits. Locality: Sea coast of Takatsuka, Toyohashi City, Aichi Prefecture.

Plate 8–Partial badland topography, gullies and transported sand-pillars adhering to the face of the siltstone. Locality: Sea cliff below Tonami, Toyohashi City, Aichi Prefecture.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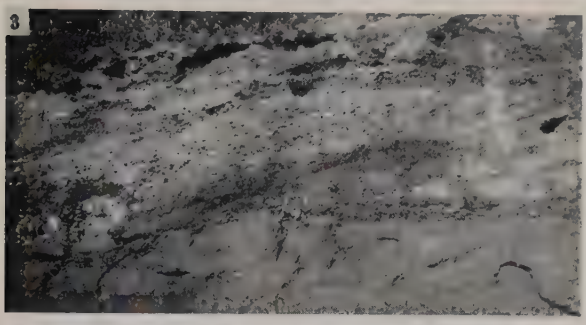
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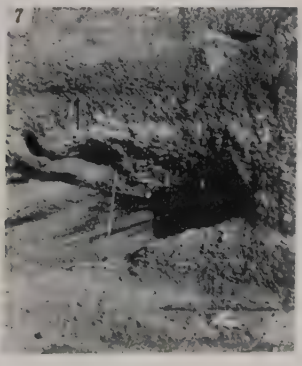
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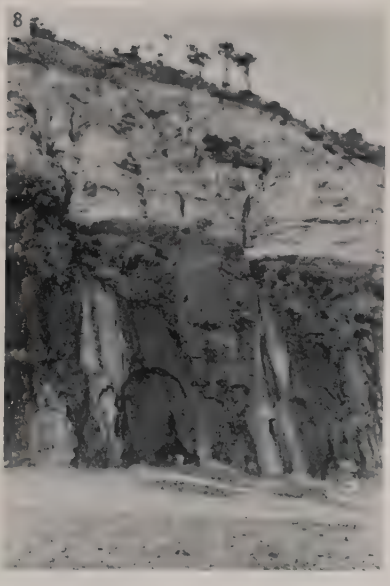
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SOME CYLINDRICAL AND TABULAR STRUCTURES FROM WAKAYAMA PREFECTURE, KII PENINSULA

By

Kotora Hatai* and Takehiko Iwai**

(* Department of Geology, Faculty of Education, Tohoku University
** Department of Geology, Faculty of Education, Hirosaki University)

Introduction and Acknowledgements

There have been described from the Tertiary rocks of Japan many different kinds of pipy or cylindrical structures (see references), which have been ascribed to the work of organisms on the one hand and to inorganic agencies on the other. These structures which have been attributed to organic origin agree with one another in being preserved in rocks of marine origin, exhibiting more or less circular cross-sections, showing either longitudinal striations or irregular markings on their surfaces, consisting generally of medium to coarse grained sands, and in being either upright in position or with inclinations of various angles. Similar reports have been published for analogous structures from Tertiary or earlier rocks of other countries (see references). The cylindrical structures described as of inorganic origin, that is to say, to uprising waters, generally have smooth external surfaces.

During the winters of 1957 and 1958, some pipy or cylindrical and tabular structures were observed in a Miocene sandstone developed in and near the Cape Torinosu near the Seto Marine Biological Laboratory of the Kyoto University at Shirahama, Nishi-Muro-gun, Wakayama Prefecture. Since these observed structures diverge widely from those hitherto reported from Japan, the writers feel that their descriptions and interpretations will contribute to our knowledge on the problematica.

Taking this opportunity the writers thank Dr. Hiro Utinoumi of the Seto Marine Biological Laboratory of the Kyoto University at Shirahama, Wakayama Prefecture, for his courtesy during the writers' visit to the Laboratory. Thanks are due to Japan Society for the Promotion of Science for making the necessary arrangements for field work. For the valuable discussions and suggestions concerning the origin of the cylindrical and tabular structures described in this article, the writers are obliged to Professor Gunjiro Sakai of the Department of Geology, Faculty of Education, Hirosaki University, to whom their deep appreciation is extended.

Location and Stratigraphic Position of the Structures

The pipy or cylindrical and tabular structures to be described were found embedded in a medium grained sandstone, yellowish on weathered and bluish-gray on fresh surfaces, developed around the northern side of the small village of Uranouchi and building the cliffs along the northeastern side of Cape Torinosu, about three kilometers immediately south of Tanabe City, Wakayama Prefecture. The sandstones of the above-mentioned two localities are situated nearby and belong to the same stratigraphic position as those in the Tomita formation of the Kanayama group of Takeyama (19~30).

The Tomita formation, especially the sandstone in which the pipy or cylindrical and tabular structures were found is Miocene in age from the occurrence of *Turritella kiiensis* Yokoyama besides other mega-molluscan fossils. Thus, from the molluscan fossils it is evident that the formation is marine in origin, deposited in shallow water and under the influence of the warm thermal conditions then prevailing.

Descriptions of the Cylindrical and Tabular Structures

The structures to be described are in general parallel with the dip of the strata in which they are preserved. The pipy or cylindrical ones are varied in their relation with the general dip of their entombing stratum, the majority being parallel or nearly so and the minority are from vertical to about ten degrees with the general dip. The vertical or variously inclined ones usually connect with the horizontal ones, but may occur independent of the horizontal pipy structures. The tabular ones are always found to be almost parallel with the dip of the sandstone stratum. Both cylindrical and tabular structures are characteristic in having their external surfaces fringed with a coating of limonite, generally showing no internal structures, consisting of the same grain sizes as the sandstone matrix so far as megascopic observations are concerned, and in having considerable lengths so far as they are exposed. These two types will be described separately.

Cylindrical or Pipy Structures

These structures measure from about one centimeter up to eight or ten centimeters in diameter and more than three meters in length because they appear to extend farther into the sandstone which preserves them. Through the observed length they are found to vary in their diameter because the exposed terminal portions, which are bluntly pointed or end rather abruptly are generally observed to become larger towards the opposite direction. All, however, agree with one another by having their external surface sculptured with irregular, more or less rounded, tubercular or wavy protuberances which are transverse in development and the whole fringed with a coating of limonite.

The transverse protuberances may measure 15 millimeters in length, up to nearly ten millimeters in width and five millimeters in height. These may be

equally or unequally spaced, show more or less definite arrangement or be at random, but are generally better developed on the lower than on the upper sides.

The transverse wavy markings closely resemble flowage sand in showing overlapping of more or less scale-like aspect, appearing as if accumulated by compressive forces, and their arrangement may be close-set or separated by distances of about several to ten millimeters, and in length they exceed four centimeters (distinctly observed and measurable length; gradually merge into the sand making the structure).

In shape the pipy or cylindrical structures may be slightly curved in very broad bow-shape, nearly straight, sigmoidal in plan-view, semicircular to nearly circular in plan-view, provided with branches where develop elbow-like, buldging and variously shaped enlargements in cross-section, and also variously branched in plan-view. None of the tubular structures has the same or similar diameter throughout their observed lengths, all are provided with some kind of transverse sculpture, rarely with longitudinal ornamentation in the form of striations or protuberances, and their irregularity in both shape and sculpture seems to be a characteristic.

In arrangement these structures, the majority of which is long and parallel or nearly so to the dip of the entombing stratum, while the minority of which comprises those of various inclination from about ten to 90 degrees to the bedding plane, are generally dense and shorter in length. One outcrop measuring about two and a half meters in height had its whole surface densely crowded with the pipy or cylindrical structures. The same may be said for both cross-section and plan-view, which are illustrated in the annexed plates. It may be added that the density is not uniform in all of the exposures since such a phenomenon would not be expected for such structures of inorganic origin as discussed in later paragraphs.

Tabular Structures

Occurring in the same sandstone in which the pipy or cylindrical structures were found are tabular structures of particular shape, size and significance. These tabular structures resemble the tubular ones in their external surface being generally coated with limonite, showing variation in their thickness and width and also in details of morphology. However, they all can be distinguished from the tubular structures by being tabular, showing pinching, and by the peculiar structures developed therefrom. For this reason they are described as a structure to be distinguished from the tubular ones.

These tabular structures measure from about one or less centimeter up to about ten centimeters in thickness, from several to about 60 centimeters in width, and although partially discontinous at places the length is considered to exceed four meters because they extend into the sandstone which preserves them.

Upon the external surfaces of these tabular structures there could be observed sometimes, transverse wavy markings as if due to flowage sand or the piling up of sand due to compressive forces, minute or incipient protuberances and small irregularities as depressions. Besides at places there are developed particularly on their underside, sharp to blunt and rather large to very small, downward injections to variously rounded or sharply rectangular structures.

In shape these tabular structures show pinching, partial detachment, lense-patches and irregular simply to variously branching masses in cross-section along their length. In cross-section along their width these tabular structures are broadly oval or lenticular, and may merge into their matrix or be stellate quite irregularly.

The peculiar structures considered to have developed from the tabular ones comprise a large variety of forms. Some of them appear as masses of short tabulates superposed vertically but have at several places along the sides of the masses protruding tubular structures or tabular extensions. Other masses appear to form a thick tabular mass as if due to the vertical accumulation of tubular structures more or less coalesced at places. Irregularly rounded masses with incipient stratification give the aspect of piled-up irregularly shaped and of various size tubes and tablets. One peculiar structure consisted of a nearly 50 centimeters by 10 to 25 centimeters irregularly shaped cylinder having bluntly rounded bottom, and abruptly cut top was observed in the cliff behind Uranouchi village. This cylinder, if it may be called so, has several lateral tabular extensions in its lower half, and these gradually lessen in their thickness before merging into the surrounding sandstone from which they are distinguished by the thin coating of limonite on their surface. Whether these mentioned peculiar structures are an outgrowth of the tabular or cylindrical structures remains to be settled, but the fact that these types occur in sandstones only where cylindrical and tabular structures are found suggests that their origin may have intimate relation with that of the tubes and tablets.

Considerations on the Cylindrical, Tabular and Peculiar Structures

Interesting papers on cylindrical structures standing upright or at some angle oblique to the bedding plane have been published by Hawley and Hart (1934), Gabelman (1955) and others (see references). Among these reports, cylindrical or tubular structures due to organic and inorganic agencies are described. However, it seems that there are no reports dealing with tabular or the peculiar structures described in the present paper, so far as the available literature is concerned. For such reason explanations for their origin that can be interpreted from field and literature, will be attempted in later paragraphs.

Gabelman (1955) who treated the cylindrical structures found in the Permian siltstone in Eagle County, Colorado, recognized eight types in the form of the cylinders he studied. All of these types are assigned to development by uprising water. On the other hand, Hawley and Hart (1934) made experiments in

loose sand and produced cylinders similar to those found in the Potsdam sandstone, which were reported by Gabelman (op. cit.). Cylinders of similar origin have been reported by Arai (1959, MS) based on examples from the Tertiary rocks of the Chichibu Basin in Saitama Prefecture, Japan. Cylindrical or tubular structures described as sand-pipes from several localities of the Tertiary rocks of Japan, have been assigned to the makings of marine annelids, crustaceans and molluscs (bivalves) by several authors (see references). These which have been described as of organic origin diverge from the ones treated in the present article by being associated with fossils of those groups, having quite different external sculpture, and unsimilar orientation in the strata in which they occur. These types are, therefore, not included in the explanations given below.

Since the structures described in this paper are essentially horizontal or parallel with the dip of the stratum in which they occur, fail to reveal the characteristics described by authors for cylindrical structures having oblique to nearly or quite perpendicular relationship with the bedding plane, diverge from the features described for tubular structures of organic origin, and suggest an inorganic origin, the writers feel that the following explanation may be a probable view.

Interpretation of the Cylindrical, Tabular and Peculiar Structures

The pipy or cylindrical structures which are horizontal and widespread in the Tomita formation are considered to be analogous with the horizontal cylinders or pipy concretions occurring in the Miocene Arikarec formation of Nebraska and Wyoming. According to Gabelman (1955), the horizontal cylinders in the Miocene Arikaree formation just mentioned are believed to have resulted from the movement of lime-charged ground water flowing through permeable sandstone controlled by gravity-flow. Calcium carbonate was precipated as a cement forming tubular or pipy concretions as plugs in the original ground water channels. These cylinders, as in the present case, are said to be characterized by their strong irregularity in diameter and surface features. He also adds that vertical pipes are rare and exist only as connections between horizontal pipes.

The horizontal cylinders of the Tomita formation agree with those from the Arikaree formation of Nebraska and Wyoming in all features, so far as it can be judged from the accessible literature. However, as to the tabular and peculiar structures occurring in the Tomita formation, it seems that there are no published descriptions with which comparison can be made.

As in the case of the horizontal cylinders and pipes, it is thought that the tabular structures described in earlier pages of this article, are also the result of underground water. The differences in shape and size of the tabular structures compared with the horizontal cylinders, are considered to be due to

the position of the water body, direction and amount of flow, permeability of the sandstone, and diagenesis at the time of water flow.

Then it is considered that underground water does not flow in sheet form, but rather in the form of channels whose magnitudes and shapes may vary according to the permeability, porosity and conditions prevailing during and after deposition of the stratum as well as to the distance, inclination of flow and amount of source water. Underground water upon reaching a contemporaneous, penecontemporaneous or planeless fault may be temporarily dammed up to form a water body in a position different from the original one from which it became detached or isolated. Filling of such a water body may lead to the development of a water-fall. From such considerations, it follows that the morphology, extension and horizons within a single sandstone of underground water channels would be varied.

The detached or isolated masses of irregular shapes and different sizes described in the earlier lines as well as the tabular structures are all believed to be the result of underground water. Although these structures appear to be isolated and very irregular in their morphology, it is also to be considered that some of the thin covering of limonite may have been eroded away on one hand and originally not uniformly precipitated on the other, thus resulting in their present exposed features.

The irregular shaped cylinder mentioned in early lines of this paper, from its morphology, position in the sandstone, relation with adjacent horizontal cylinders and tabular structures, is thought to have been the result of either a water-fall or the sinking of water along a joint or crevice as may be judged from the shape of its bottom and its vertical position on whose left side are developed tabular structures, but separated therefrom by a distance of about 30～40 centimeters.

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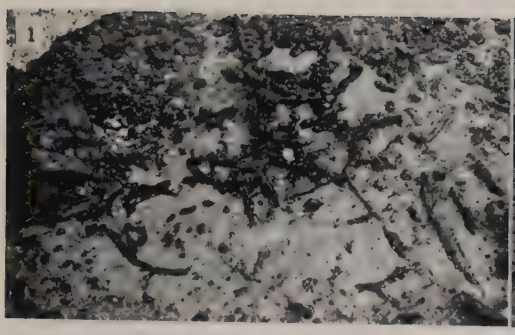
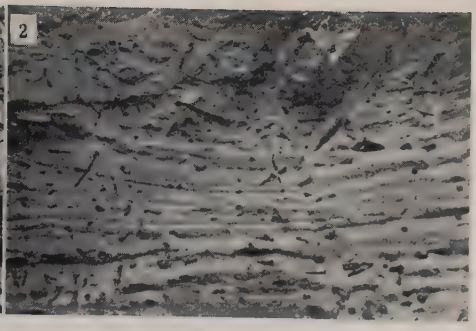
Explanations of Plates

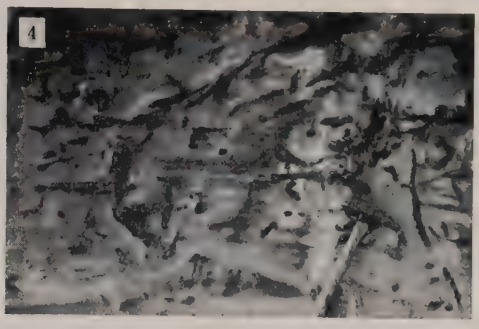
Plates 1, 3, 5 and 6. Horizontal pipes in plan-view weathered out of the Tomita formation on the southwest side of Cape Torinosu. Notice the shapes and variation in their diameters along their lengths. Embedded in medium grained sandstone and all are covered with a thin layer of limonite.

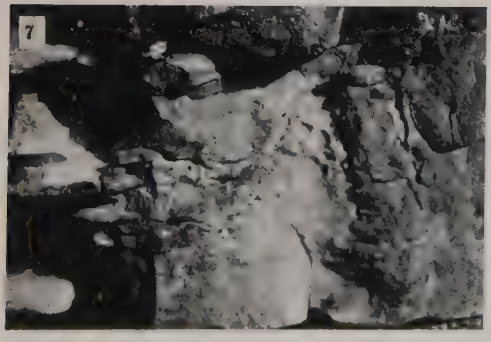
Plates 2 and 4. Mode of occurrence of the sand-pipes. All are horizontal except for those which connect the horizontal ones. Note the peculiar branching and bluntly rounded terminal portions of them. Locality-northeast side of Cape Torinosu.

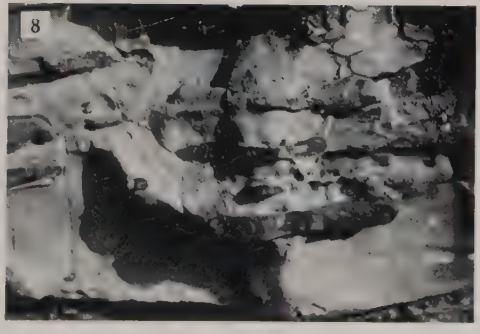
Plates 7 and 8. Horizontal layers and cylindrical structures observed in the Tomita formation behind the village of Uranouchi opposite the landward part of Cape Torinosu.











Hatai Photo

Records of Oceanographic Works
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March 1960

MEASUREMENTS OF PERPENDICULAR AND HORIZONTAL ANGULAR DISTRIBUTIONS OF SUBMARINE DAYLIGHT BY MEANS OF A NEW REMOTE CONTROL INSTRUMENT

By

Tadayoshi Sasaki*, Seiichi Watanabe**, Gohachirō Ōshiba**
and Noboru Okami**

Introduction

Since 1954 the authors have carried out measurement with respect to what effects the solar altitude, conditions of the sky and the surface of the sea, turbidity of sea-water, depth of the points, at which measurements were done, and others have upon the angular distribution of submarine daylight.[1)-5)]

In 1958 the authors studied and constructed a new instrument of remote-control-type usable in depth within 100 m for measuring angular distribution of submarine daylight in both perpendicular and horizontal planes. Using this new instrument the authors carried out experiments in Sagami Bay in February–March and in August, 1959 and consequently reported the structure of the said instrument and the results of measurement.

Explanation of the Instrument

On the occasion of planning the new instrument the authors decided to omit the bearing indicator though it had been attached to the instrument for the horizontal angular distribution.[4) 5)] Because from the results of previous measurement it had been found that the direction of the maximal value of angular distribution of submarine daylight in any horizontal plane is always identified with the solar bearing and accordingly the relation between the solar bearing and the rotating plane of the perpendicular light receiver can be found from on board when the perpendicular light receiver itself and its mechanism of rotation can be rotated simultaneously with the horizontal light receiver.

The instrument consists mainly of submerged unit, unit on board and cable. The submerged unit consists of light receiver in horizontal plane (called horizontal light receiver), light receiver in perpendicular plane (called perpendicular light receiver), revolving mechanism and angle indicator for rotation. The unit on board consists of operating unit, stabilized DC high-voltage power supply

* Tokyo University of Fisheries and Rikagaku Kenkyūsho.
** Rikagaku Kenkyūsho (The Institute of Physical and Chemical Research), Tokyo.

and indicator for light intensity. The submerged unit hung down by cable is shown in Fig. 1, the general arrangement of submerged unit is shown in Fig. 2, the electrical circuit of submerged unit is shown in Fig. 3 and that of operating unit on board is shown in Fig. 4.

The submerged unit is hung down through the swivel piece containing stainless balls by the main cable. The single core insulated wires branched off from the main cable having seven-core in the junction box are connected with motor, light receivers and others through the gland stuffing boxes. To the junction box a rudder having an area of about 1,000 cm^2 is so attached as to stabilize the instrument in a horizontal plane. In the box-shaped water-tight housing two geared motors for horizontal and perpendicular rotations and automatic reversing switches are placed. As the vertical shaft placed in the upper part of the housing is fixed to the junction box, the housing is rotated horizontally together with the horizontal light receiver placed at the bottom of the instrument when the motor for horizontal rotation is revolved so that the light intensity in the horizontal plane may be measured.

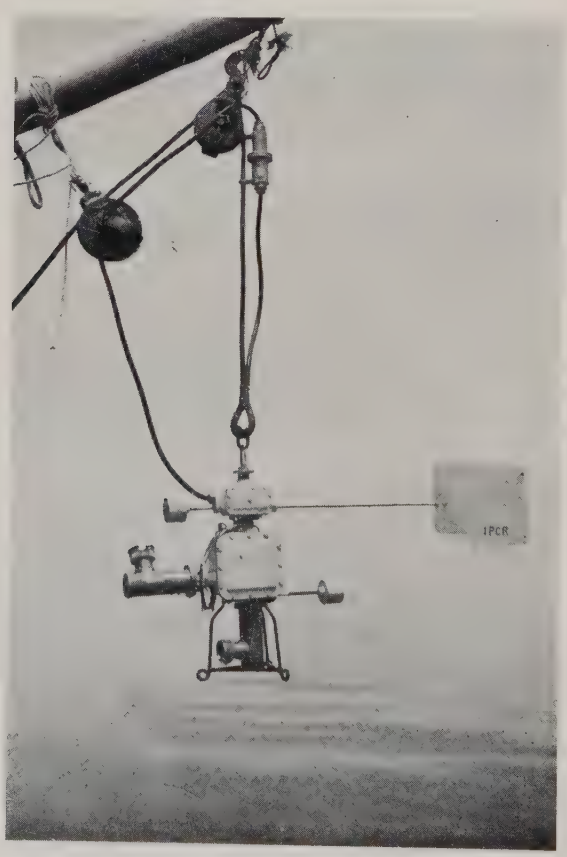


Fig. 1. Submerged unit before lowering

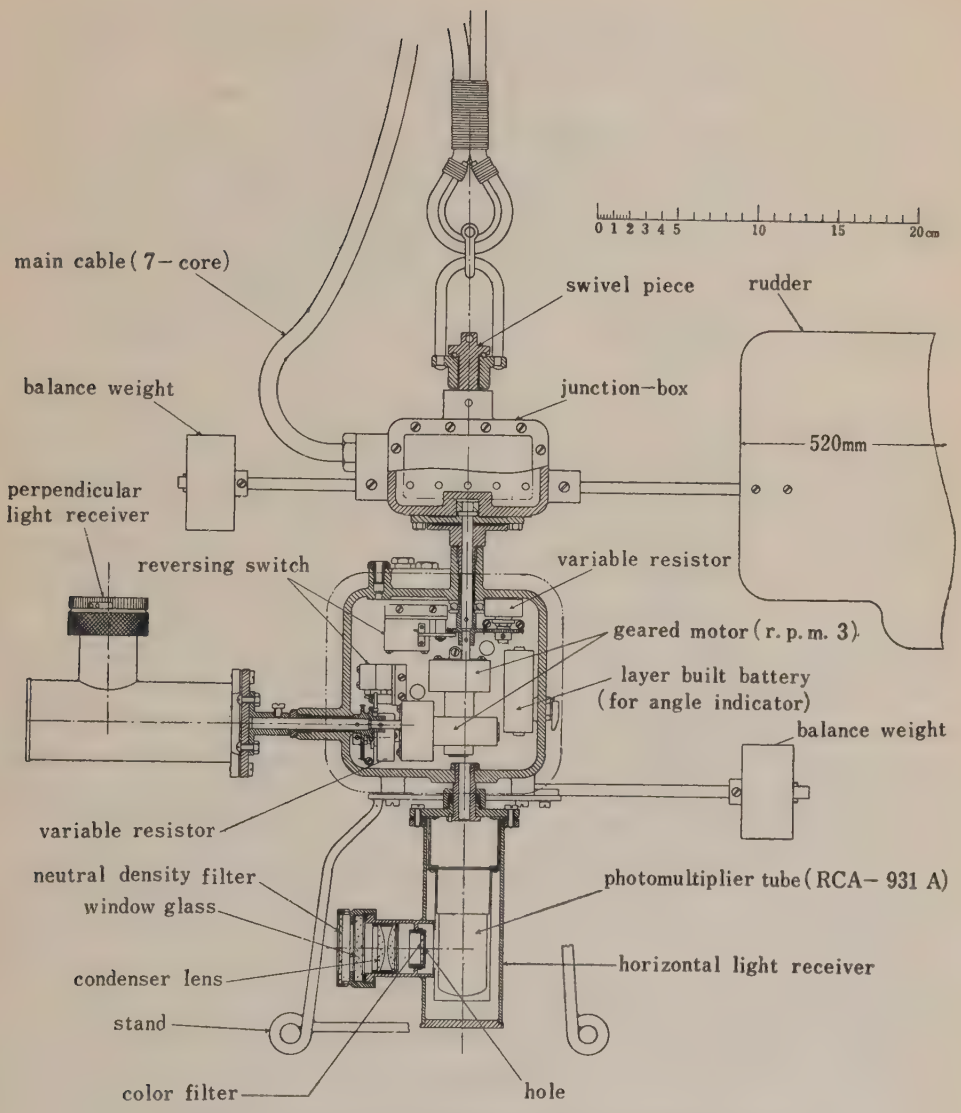


Fig. 2. General arrangement of the submerged unit

The horizontal light receiver: The horizontal light receiver is attached to the bottom of the box-shaped housing and it can be rotated at an angle of 90° by means of hand on board. This is intended to rotate the perpendicular light receiver in the perpendicular plane including the sun and the other perpendicular plane rectangular to the former. In the case shown in Fig. 2, where the optical axis of the horizontal light receiver is parallel to the shaft of the perpendicular light receiver, if the maximal light intensity be received by the horizontal light receiver, the perpendicular light receiver will be rotated in the perpendicular plane rectangular to the other perpendicular plane including the

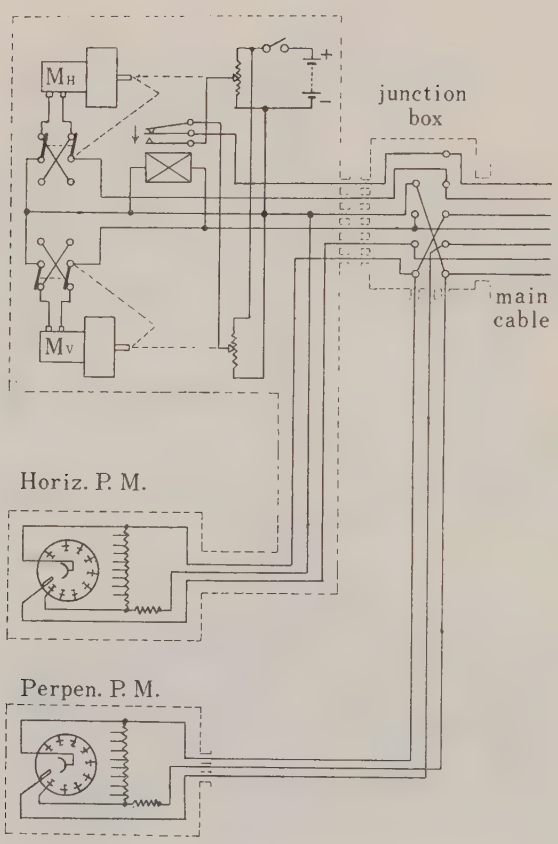


Fig. 3. Circuit diagram of the submerged unit

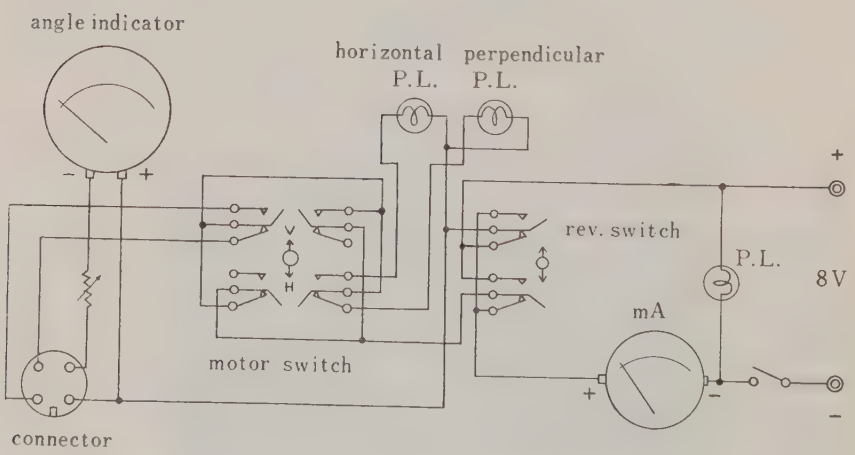


Fig. 4. Circuit diagram of the operating unit on board

sun. And if the horizontal light receiver be rotated at an angle of 90° on board light intensity in the perpendicular plane including the sun will be measured.

The inner structure of the light receiver is shown in the lower part of Fig. 2. The structure and property of the light receiver are the same as those of the instrument for the horizontal angular distribution.[4) 5)] Its directional character is about 5° and the center of gravity of the spectral sensitivity curve including the color filter and the photomultiplier tube is 520 mμ.

The perpendicular light receiver: The main structure and the property of the perpendicular light receiver are the same as those of the horizontal light receiver.

The revolving mechanism: Two small geared motors (3 r.p.m.) for perpendicular and horizontal rotations are placed in the box-shaped housing. The motor for perpendicular plane is connected with the perpendicular light receiver and is reversely rotated by automatic reversing switch so as to prevent the single core insulated wires from twisting when the perpendicular light receiver has rotated at an angle of about 340°.

As the vertical shaft for horizontal rotation is fixed to the junction box, which is stabilized by the rudder, if the motor rotates, the box-shaped housing having the two light receivers will rotate on the fixed vertical shaft and if the housing rotates at an angle of ca. 340°, the motor will automatically reverse. The properties of these small motors are; voltage 7.5 V DC; current 33 mA; gear ratio 1,520; revolutions per minute 3; rotating torque 2.5 kg-cm.

Indicator for rotating angle: Indicator for rotating angle for perpendicular and horizontal light receivers consists of a B-type variable resistor interlocking a rotary shaft by means of gears, battery (22.5 V), relays and the angle indicator on the operating unit on board. Divided voltage in accordance with the rotary angle of each light receiver is introduced to the indicator for rotary angle so as to indicate the angle to which each light receiver points. The angle, where the perpendicular light receiver points to the zenith, is assumed to be 180°. The range between 90° and 270° is graduated at every 10° and other range is graduated at every 30°.

The horizontal rotary angle can be indicated by the same indicator as that of the perpendicular rotary angle during the rotation and if the rotation be stopped, the said indicator will automatically indicate the rotary angle of the perpendicular plane.

Operating unit: The operating unit is intended to control the rotation of light receivers of photometer from on board and has an angle indicator for rotation of light receivers, a non-locking reversing switch for correcting small over-rotation, pilot lamps and an ammeter. The power source supplies the operating unit with 8–10 V DC and the current needed is 150–250 mA.

The explanation of stabilized high-voltage power supply, indicator for light intensity and cable is omitted.

Results of Measurement and Discussion

Several results of measurement carried out in Sagami Bay in February–March and in August, 1959 are described below.

The angular distribution of submarine daylight in case of rotating the perpendicular light receiver in the perpendicular plane including the sun at 15:00 on February 27, 1959 is shown in Fig. 5. The pattern of angular distribution at a depth of 5 m has the maximal submarine daylight intensity in the direction of 150° and shows a considerably strong directivity. With increase of depth the pattern resembles an egg-shape, where the maximal value moves toward the direction of 180°, viz. the zenith and the maximal intensity of light decreases gradually, but in this figure read values of photoelectric current in case of changing the voltage of power supply are shown without correction and the shape of decreasing intensities is not shown.

The pattern of angular distribution of submarine daylight at a depth of 60 m on March 2, 1959 in the perpendicular plane including the sun and that in the other perpendicular plane rectangular to the former are shown side by side in Fig. 6. The former pattern is of egg-shape having its maximal intensity in the direction of 185° and the latter pattern is also of egg-shape having its maximal intensity in the direction of 180° independently of depth.

In the two experiments described above for the purpose of rotating the perpendicular light receiver in the perpendicular plane including the sun or the other perpendicular plane rectangular to the former the horizontal light receiver is operated to point to the incidental light having the maximal value. As it had been found that to search the maximal intensity of incident light becomes gradually difficult with increase of depth and turbidity of the sea and cloudiness of the sky and becomes much more difficult especially when the solar altitude is near the zenith, the authors measured in August, 1959 the angular distribution of submarine daylight in the perpendicular planes by another method different from that described above. The new method is described below.

The perpendicular light receiver is at first let face the direction of 180° and measurement of light intensity is done and then the said receiver is let face the direction of 190° and the instrument is stopped at every 30° during a revolution in the horizontal plane and measurement of light intensity is done. Then the perpendicular light receiver is let face the direction of 200°, 210°, 240°, 300° and the similar measurement described above is carried out. Accordingly the light intensity at each of nearly 90 points on the spherical surface centering around the instrument is measured. As the perpendicular light receiver is let face the direction of every 10° from 180° to 210° viz. the neighborhood of the solar altitude and then that of every 30° from 210° to 330°, the spherical surface is not equally divided, however, if the spherical surface be too finely divided, the time necessary for measurement will be increased.

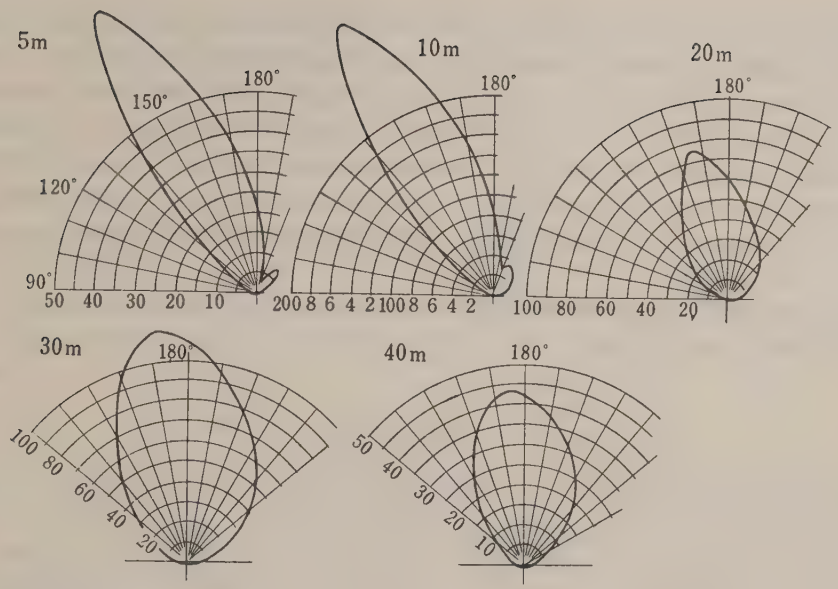
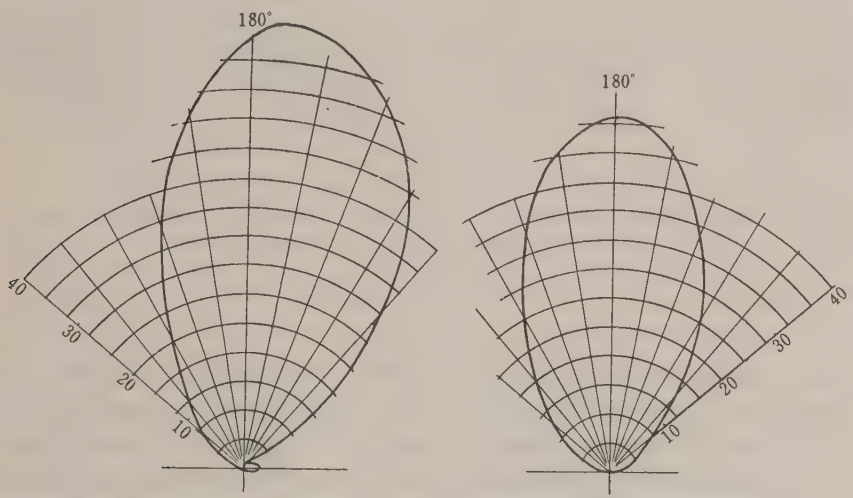


Fig. 5. Light vector diagram in perpendicular plane including the sun, at several depths, off Itō 15:00~15:25 Feb. 27, 1959



Perpendicular Plane including the sun

90° perpendicular section

Fig. 6. Light vector diagram in a perpendicular section, at a depth of 60 m, off Itō, Mar. 2, 1959

As this measurement aims at knowing the angular distribution in all directions, for the purpose of obtaining the pattern of the angular distribution of submarine daylight in the perpendicular plane including the sun as shown in Fig. 5, the said pattern may be drawn using the maximal and minimal points

of the diagram of light intensity in case of letting the instrument rotate in the horizontal plane at each inclination of the perpendicular light receiver. Using each value in each direction rectangular to that, where each maximal value lies, the pattern of the angular distribution in the perpendicular plane rectangular to the other perpendicular plane including the sun is obtained. The new method of measurement and the patterns of angular distribution described above are useful for increasing the accuracy of angles but the time necessary for measurement is prolonged.

Patterns of the angular distribution at depths of 20–60 m measured by this method are shown in Fig. 7.

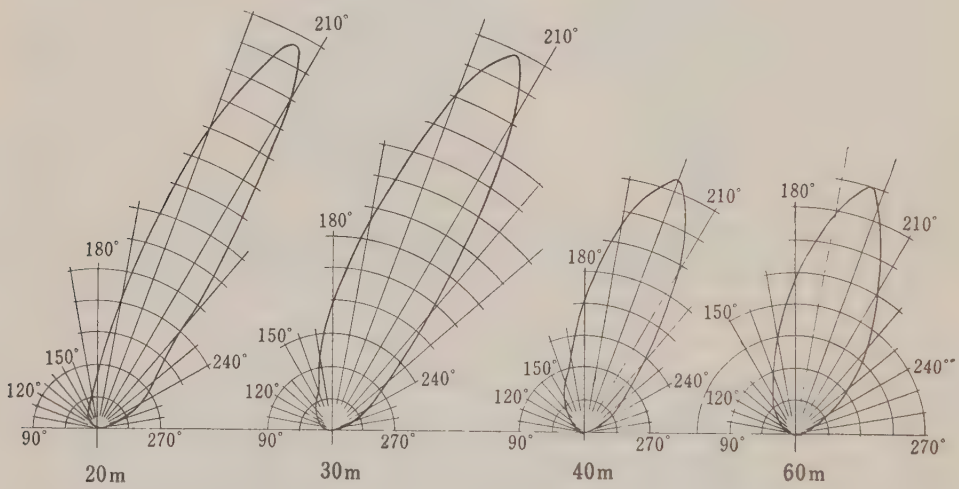


Fig. 7. Light vector diagram in perpendicular plane including the sun, at several depths, off Itō 14:00~14:11 Aug. 19, 1959

Conclusion

The results of measurement by the new instrument for measuring angular distribution of submarine daylight in perpendicular and horizontal planes are similar to those using the underwater observation chamber "Kuroshio" and it is found that this instrument is generally useful. However, from the result of examining the directional angles it is noticed that the operation, by which the patterns shown in Fig. 7 were obtained, must be performed for the purpose of increasing the accuracy. This method has defects of taking longer time to measure and to arrange the results of measurement as compared with the method previously described. In performing this method the horizontal light receiver is not used and consequently if the horizontal light receiver be let face the zenith and the fluctuation of the intensity of incident light be observed, prolongation of the time necessary for measurement will be avoided and the accuracy of measuring light intensity will be increased. Moreover, if the horizontal light receiver be

almost adjusted to the incident angle of submarine daylight and then the receiver rotated so as to search the maximal intensity of the incidental light, the accuracy of the method, by which the patterns shown in Figs. 5 and 6 were obtained, will be increased.

It is convenient for performing frequent experiments that this instrument is rather small and light. Using this instrument the authors will carry on studies for oceano-optical subjects as environmental factor of sea organisms.

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CAPPED CYLINDER BACKET

By
Magoshichi Sato
(Japanese Hydrographic Office, Maritime Safety Board)

Construction

This instrument is designed by the author and manufactured by Tsurumi Seiki Kosakusho Co. Ltd. It has a cylindrical form and its length is 1120 mm, diameter 128 mm and total weight 35 kg (main weight: 27 kg, cylinder backet: 8 kg). The device is composed of cylinder backet (a in Fig. 1), and main weight (b in Fig. 1), which are connected by the iron rod of 10 mm diameter. Conical iron cap (d in Fig. 1), loosely fitted, is mounted on the rod between cylinder backet and main weight.

Although the gear is large in size and weight for the purpose of deep sea dredging, the smaller gear is favorable to the shallow sea dredging such as on the continental shelf shallower than 500 m in depth. On the shallow shelf, accordingly, the use of small "Sato Cylinder Backet", which is without cap and its weight is connected with cylinder backet merely by holding line, brings good results. In case of this capless backet, however, slowly hoisting of the gear is necessary for prevention of washing out of sample.

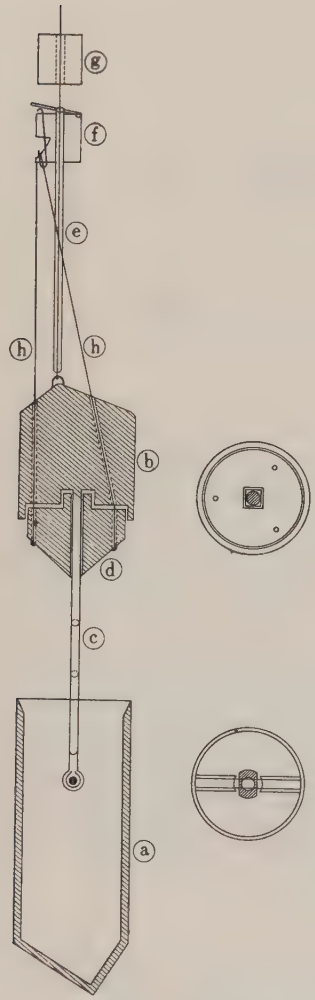
Merits

Formerly, dredged sediments such as lutite were washed away during hoisting for the increase of hoisting speed. By the use of this device, one can prevent the dredged from washing away and collect the water just above the sea bottom.

Further using strong wire rope, one can dredge even the rocky bottom by this device.

Operation

Connect the gear to lowering wire rope and lift it to the side of ship. Next, raise up and insert the conical cap to the bottom of main weight, and hook the holding line to release apparatus (f in Fig. 1). Then, lower the gear to sea bottom. The gear is dragged on the bottom for the shift of vessel by wind and current (or rolling of ship). After brief hoisting until the gear is hanging slightly above sea bottom, messenger must be sent down and hit



a cylinder backet
b main weight
c iron rod
d conical cap
e iron tube
f release apparatus
g messenger
h holding line

Fig. 1. Construction of Capped Cylinder Backet

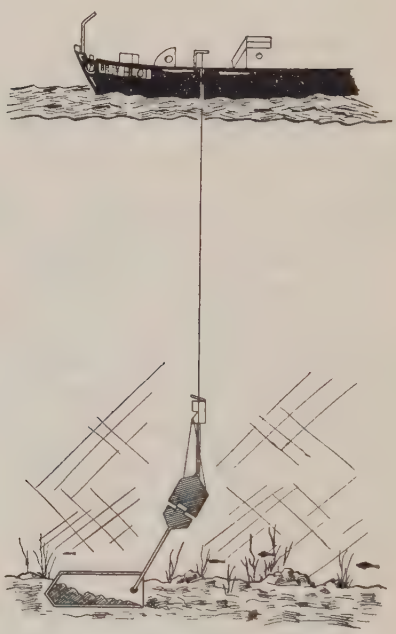


Fig. 2. Dragging of the gear on sea bottom

the lever of release apparatus. Then the holding line is released and the conical cap slides along the rod and shuts the entrance of backet.

Results of Experiments

Because the main weight is fixed to cylinder backet by rod, the backet is horizontally dragged on bottom and successfully dredges sediments during the shifting and rolling of vessel.

As the gear does not rotate during the lowering and hoisting, the wire rope is not apt to kink and break. This is because of that the wire rope is connected with main weight at the point, little apart from the center of the latter.

Release apparatus, fitted at the top of iron tube (e in Fig. 1), operates successfully in spite of the rotation of the gear and wire rope.

Some improvements are intended in the light of the results of future experiments.

The results of analysis of sea water just above the bottom will be reported in another article.

Plates. Dredging operation on board of MEIYO

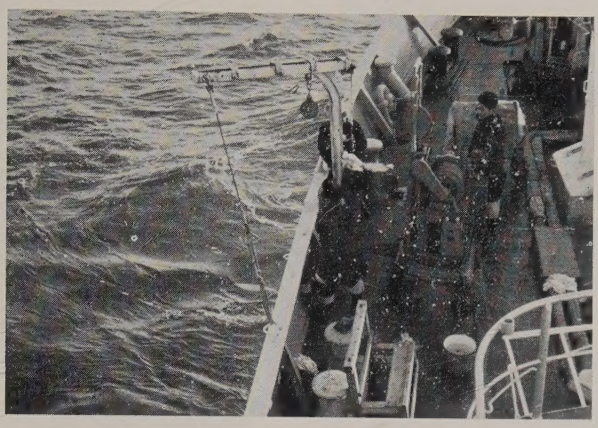


Plate 1. In operation

Plate 2. Dredged bottom sediment

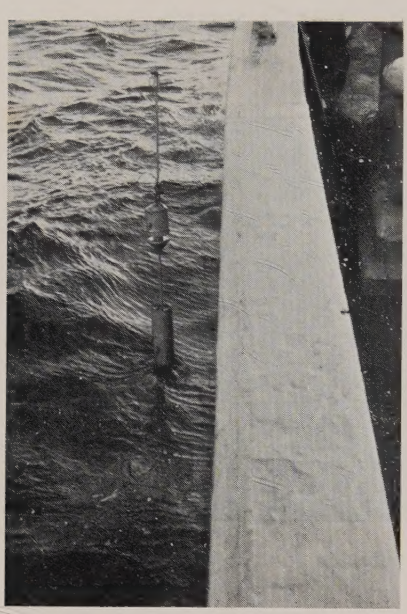


Plate 3. In lowering

Plate 4. Setting of release apparatus

Plate 5. Sliding down of cap